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ABSTRACT

This is the teacher's edition of one of the eight units of the Intermediate Science Curriculum Study (ISCS) for level III students (grade 9). This unit and its activities focuses on environmental pollution and hazards. Optional excursions are suggested for students who wish to study an area in greater depth. An introduction describes the problem of air pollution, pesticides, water pollution, and population increases. Illustrations accompany the text. (SA)

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TEACHER'S EDITION

Environmental Science

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Probing the Natural World / Level III

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An Introduction

Man has survived on this planet for many thousands of years and has proved to be a most successful species. He has populated the planet, subjected other species to his own use, and developed new processes that match many natural processes in both intensity and scope.

Suddenly we find reason to question his success. The power that man has exerted on the rest of nature now threatens his own survival. If we are surprised to find ourselves in a deepening environmental crisis, we can, at least, be encouraged by the current awareness of the crisis. This awareness is necessary if we are to launch a successful attack on the extremely serious problems.

Of special significance is the coming of age of a generation that has a very special relationship to the environment. Young people today are the first generation to carry strontium-90 in their bones, DDT in their fat, and asbestos in their lungs. Their bodies will record the effects of these new environmental insults on human health, since they are the involuntary subjects of a huge worldwide experiment. Although many effects have already been documented, the full significance of this experiment will be discovered only after this generation has lived out its life. Only then will we have learned the long-term biological effects of so many novel agents, some of which interact to cause even greater effects than the sum of each taken separately. So it is our young people—and future generations—who may have to bear the ultimate consequences of today's environmental hazards.

AIR POLLUTION

The problem of air pollution is not new, although its recognition as a problem is. Only yesterday, people regarded a smoking factory chimney in their town as a sign of prosperity in which to take pride. The sweet smell of money, jobs, and taxes was quite tolerable. However, as the population grew and industrial wastes multiplied, air pollution reached a stage that was no longer acceptable to large numbers of people.

T3

The earth's atmosphere is limited. Understanding its composition, as well as its limitations, is necessary in order to understand how it became polluted. Unfortunately, we know little about the nature and abatement of air pollution because atmospheric research is relatively recent.

The density of the atmosphere decreases with altitude, and approximately half the atmosphere by weight lies below 5,500 meters. It contains about 21% oxygen, which animals, including man, require for life. Other constituents of air include variable amounts of water vapor, nitrogen (78%), and carbon dioxide, carbon monoxide, and certain other gases, all of which total less than 1% by weight.

The atmosphere is influenced by many factors, both natural and man-made. Heat energy from the sun is the chief influence. Heat is a form of energy as well as an expression of molecular activity. Because different materials have different molecular structures, they will have different temperatures when they are heated. Land, for example, becomes hotter than water when identical amounts of heat are applied to both. So differential heating and cooling between mountains and flat land, desert and cultivated land, green plants and pavement, etc., all influence atmospheric conditions.

The troposphere is the layer of the atmosphere adjacent to the earth. Normally the temperature of the troposphere decreases with increasing altitude. Sometimes conditions exist in which there are changes in this order. For example, there may be a narrow layer within the troposphere in which temperature increases with altitude for several hundred meters. This is called a *temperature inversion,* since it is an inversion of the usual decrease of temperature with altitude. Inversions can hinder the rise of the air, and if this air contains pollutants, the inversion acts as a lid to seal them below. If there is no wind, then the stage is set for an acute air pollution episode, such as occurred in New York City in July 1970.

Of the hundreds of pollutants, some are of major importance to man's well-being. These are briefly described below.

Carbon monoxide The complete combustion of carbon in the presence of oxygen results in the formation of carbon dioxide (CO_2). Carbon monoxide (CO) results from the incomplete combustion of carbon, and it has been considered almost exclusively a man-made pollutant. It is toxic to humans at concentrations of 100 parts per million when exposure for several hours occurs. Although carbon monoxide is produced largely by incomplete combustion of fuel, predominantly from automobile engines, recent research indicates that the oceans and the atmosphere itself are contributing through photochemical oxidation of organic matter.

Carbon dioxide CO_2 occurs naturally as a by-product of animal respiration, and in other natural events such as volcanic eruptions. A very large proportion of atmospheric CO_2 also results from the combustion of fossil fuels such as coal, oil, and gas. Since the Industrial Revolution, man has greatly increased CO_2 emissions. It is estimated that man-made emissions of CO_2 will show an eighteenfold increase from 1890 to 2000.

T4

Because of these additions, carbon dioxide enters the air at a faster rate than the natural carbon cycle can adjust to it. This results in the slow, but measurable, buildup of carbon dioxide in the atmosphere.

Carbon dioxide has an effect on global temperature because of its ability to absorb heat energy (infrared radiation) and to trap energy close to the earth. This has the net effect of allowing less heat to escape into outer space, and is appropriately called "the greenhouse effect." Since short wavelength energy (ultraviolet radiation) passes through carbon dioxide, an increase in CO_2 concentration with a more or less constant supply of solar energy should result in increasing global temperatures. Many scientists attributed the rise in mean global temperatures in the sixty-year period following 1880 to the approximately 7 percent increase in atmospheric carbon dioxide concentration. The decrease in mean global temperature noted since 1940 may be due to increases in water vapor and atmospheric turbidity from air pollution, resulting in less incoming energy reaching the earth.

Nitrogen oxides Oxidation of nitrogen and release of nitrogen oxides into the atmosphere result largely from automobile and electric power plant sources.

Some of the oxides of nitrogen are oxidized further to nitrogen dioxide, which strongly absorbs ultraviolet light from the sun, creating nitric oxide and atomic oxygen (O). The latter can form ozone (O_3) in the presence of molecular oxygen (O_2). This highly reactive form of oxygen has been responsible for ozone alerts in Los Angeles.

Particulates Particulate matter is enormously widespread. In New York City, dustfall levels as high as 30 tons per square mile per month were recorded in 1969. Dustfall tends to consist of relatively heavy particles that settle close to their source. Finer particles may be carried by air currents and settle at great distances from their source. Airborne particles can scatter sunlight, reducing the amount of energy reaching the earth and provoking global temperature decreases. Global atmospheric dust levels are rising and include products from all phases of human activity.

Sulfur oxides Oxides of sulfur are emitted largely from man-made sources and are primarily released as sulfur dioxide, which may be oxidized to sulfur trioxide. The latter can combine with water vapor to form sulfuric acid mists that are highly corrosive to building materials, including stone and marble. When precipitated into water via rainfall, sulfur products increase acidity and can destroy aquatic life.

Lead Lead enters the atmosphere largely from burning leaded gasoline. About 65 percent of the lead in combusted gasoline is released into the atmosphere and results in both local and distant fallout. It is estimated that the Northern Hemisphere contains a thousandfold surplus of lead above and beyond natural base levels because of man's contributions.

There are numerous other atmospheric pollutants, many of whose effects are still unknown. For example, the combustion of some plastic containers can result in the formation of totally new products, reacting chemically in the atmosphere in ways completely unknown to us and producing effects that are as yet undetected or at least uncertain. Polychlorinated biphenyls, used as plasticizers in the manufacture of many products, are chemically similar to DDT and are also appearing in the environment.

PESTICIDES

In recent years, man has come to rely almost exclusively on a single means of combating pests—chemical control. These pesticides have often been only temporarily successful in eliminating the pests while having serious long-range side effects on other plants and animals in the environment.

Many of the pesticides used are sprayed in liquid form and vaporize into the atmosphere. The atmosphere cleans itself through rainfall. Water-insoluble pesticides will therefore remain in the atmosphere much longer, accumulating and spreading. Pesticides can be removed from the atmosphere as a result of their absorption on dust. This dust then falls to the earth's surface through settling, rain, or snowfall. Dustfall in areas can be quite large, and the concentration of pesticides can therefore be very high. Rain running off the land can wash the pesticides into rivers and streams, building up the concentrations in water.

Much of the controversy over pesticides centers around DDT. Unlike many organic materials, DDT has a relatively long life and is resistant to breakdown by microbes, water, and sunlight. It may travel considerable distances without losing its toxicity. When a plant or animal containing DDT dies, the DDT is returned to the soil and is ready for recycling through other living things. DDT is often concentrated in plants and in the fatty tissues of animals to a damaging extent. As large animals feed on small animals, the DDT concentration builds up. In lakes, for example, the DDT concentration in the sediments may be fairly low. The tiny invertebrates in the area may have the DDT concentration increased by a factor of 50. The concentration in the larger fish may be a thousand times higher. Gulls feeding on fish can exhibit concentrations a million times higher. Man, who is close to the top of most of these food chains, receives DDT in concentrated forms. There are few, if any, foods in the human diet free from DDT. Even mother's milk passes some DDT to infants.

There is evidence that DDT has affected reproduction in certain birds. There is as yet no evidence that man or other species will be affected in the same way. But such ecological changes are difficult to predict.

The usefulness of DDT and most other pesticides is diminishing at the same time that evidence of its destructive nature builds up. Many species of insect pests have built up a resistance to the pesticides. Most of the chemical compounds that have been developed to replace DDT have the same advantages and disadvantages. Even the newer pesticides, which break down quickly after application, can cause other ecological problems. Although work is continually being done to develop the perfect pesticide, the problem really lies in our overreliance on poisons as opposed to nonchemical means of controlling pests.

WATER POLLUTION

As man has increased in number, so has his use of water. His industrialization has led to increased amounts of waste products, many of which eventually end up in the water systems. These waste products are often complex mixtures of diverse substances. One way of describing the amount of wastes in water is to use certain collective characteristics. One of these characteristics is the biochemical oxygen demand (B.O.D.), which is a measure of the dissolved oxygen consumed in the biological processes that degrade organic matter entering natural waters. Microscopic organisms in natural waters are able to degrade (chemically break down) a large amount of wastes, but in doing so they use up oxygen from the water. The more wastes that are dumped into the water, the faster the oxygen is used up. This will therefore affect the animal life in the water, since animals depend on oxygen for survival.

Chemicals are also often added to waters to poison unwanted aquatic plants and algae. The killed weeds eventually decay and add additional nutrients to the water. This enhances the growth of additional microorganisms and further increases B.O.D.

There are certain types of wastes that cannot be degraded by microorganisms. Many pesticides fit this category, and, as we have seen, this leads to a buildup of the chemicals in the waters and their plant and animal life. Detergents posed a similar problem until a few years ago. They were originally nonbiodegradable, and consequently suds accumulated in abundance in some areas, affecting plant and animal life. Manufacturers were able to make changes in the chemical makeup of detergents, and now they are biodegradable.

THE POPULATION ISSUE

The world population is increasing at an enormously rapid rate. Most scientists agree with this statement. Views differ about just what will happen if this growth rate continues and how the rate may be slowed down before a catastrophe occurs.

Some people feel that starvation will be the ultimate check on population growth. Not all students of population accept this conclusion. Some dismiss the warning about food shortages as groundless. They argue that the world is capable of producing enough nutrients to support many times the present population. Increased production will come from the utilization of areas not now under cultivation, increases in the use of fertilizers, and—most important—the development of synthetic foods.

Our planet is overpopulated and, as a result, the human species is in the gravest danger it has faced since man first appeared on the earth. The danger is that we are running out of space—not only space for people, but space in which to dispose of the waste products of our increasingly productive economy.

We spread 48 billion (rustproof) cans and 26 billion (nondegradable) bottles over the landscape every year. We produce 365 million kilograms of trash a day, a great deal of which ends up in our fields, parks, and forests. Only one third of the 500 million kilograms of paper we use every year is reclaimed. Nine million cars, trucks, and buses are abandoned every year, and while many of them are used as scrap, a large though undetermined number are left to disintegrate slowly in backyards, in fields and woods, and on the sides of highways. The almost four billion kilograms of plastics used every year are nondegradable materials.

Thor Heyerdahl, who recently sailed from Africa to Barbados in a papyrus boat, reported that even the midocean was visibly polluted by human wastes—plastic bottles, oil, garbage, etc. With this perspective, overpopulation is not a problem for the future; it is here now, and the threat is greater for the rich nations than it is for the poor. We are running out of clear streams, pure air, and the familiar sights of nature while we still have the so-called "essentials" of life.

We are in trouble—not only the poor nations, but all of us. And not at some time in the future, but here and now—from overcrowding and the reckless misuse of our resources.

Today's media are full of information relating to pollution and conservation. One can scarcely read a newspaper or magazine without encountering such articles. Radio and television offer frequent "specials" on environmental problems. These are excellent sources for additional data and can be used when the topics in this unit are studied.

The literature is also a source of abundant information on environment. An excellent bibliography, which appeared recently, lists most of the current writings related to environmental problems. It is titled *Science for Society: A Bibliography* by John A. Moore and may be obtained free by writing to the Battelle Memorial Institute, 501 King Street, Columbus, Ohio 43201. A short list of references is given in the preface, for those wishing a general introduction to the problems of environment.

PREPARATION OF EQUIPMENT

Each chapter of the Teacher's Edition contains an equipment list for that chapter. The same is true for each excursion. In addition, the last page of each chapter alerts you to preparations necessary for the following chapter. Among the materials listed will be some items that must be supplied locally. These include friction matches for Chapter 2; baby-food jars and wax-coated milk cartons or shoe boxes for the test-tube racks in Chapter 3; liquid detergent, scissors, and paper towels for Chapter 4; fish tanks, coffee cans, and baby-food jars for Chapter 5; safety matches, jar lids, cotton, wool cloth, pieces of Styrofoam, notebook paper, and cellophane tape for Chapter 6; soil mixture, rulers, one-quart milk cartons, powdered or liquid detergent, planting containers; paper towels, and rubber bands for Excursion 4-1.

Your biggest job of preparation will be for the goldfish or minnows in Chapter 5. Details are given at the end of Chapter 4. All necessary arrangements should be made well in advance of your receipt of the fish.

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---

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MATERIALS DEVELOPMENT CONTRIBUTORS

This list includes writing-conference participants and others who made significant contributions to the materials, including text and art for the experimental editions.

Janet Anderson, *Nyack, N.Y.* Gerald R. Bakker, *Earlham College.* Frank Balzano, *F.S.U.* Harald N. Bliss, *Mayville State College.* Olaf A. Boedtker, *Oregon State Univ.* Calvin E. Bolin, *F.S.U.* Earl Brakken, *Two Harbors, Minn.* Bobby R. Brown, *F.S.U.* Robert J. Callahan, Jr. (*deceased*). Brian W. Carss, *University of Illinois.* Lois H. Case, *Lombard, Ill.* Clifton B. Clark, *University of North Carolina at Greensboro.* Sara P. Craig, *F.S.U.* John D. Cunningham, *Keene State College.* David H. Dasenbrock, *F.S.U.* Doris Dasenbrock, *F.S.U.* Jeff C. Davis, *University of South Florida.* Alan D. Dawson, *Dearborn Public Schools, Mich.* George O. Dawson, *F.S.U.* Gerrit H. DeBoer, *F.S.U.* Howard E. DeCamp, *Glenn Ellyn, Ill.* James V. DeRose, *Newtown Square, Pa.* William A. Deskin, *Cornell College.* William K. Easley, *Northeast Louisiana State College.* Donald C. Edinger, *University of Arizona.* Camillo Fano, *University of Chicago Laboratory School.* Ronald A. Fisher, *Maquoketa, Iowa.* Edwin H. Flemming, *F.U.S.* Paul K. Flood, *F.S.U.* Harper W. Frantz, *Pasadena City College* (*Emeritus*). Earl Friesen, *San Francisco State College.* Bob Galati, *Fullerton, Calif.* J. David Gavenda, *The University of Texas.* Charles A. Gilman, *Winchester, N.H.* Robert J. Goll, *Jacksonville University.* Ralph H. Granger, Jr., *Walpole, N.H.* H. Winter Griffith, *F.S.U.* William Gunn, *Miami, Florida.* John Hart, *Xavier University.* John R. Hassard, *Georgia State University.* J. Dudley Herron, *Purdue University.* Father Francis Heyden, S.J., *Georgetown University.* Leonard Himes, *Sarasota, Florida.* Evelyn M. Hurlburt, *Montgomery Junior College.* John R. Jablonski, *Boston University.* Bert M. Johnson, *Eastern Michigan University.* Roger S. Jones, *University of Minnesota.* Leonard A. Kalal, *Colorado School of Mines.* Theodore M. Kellogg, *University of Rhode Island.* Elizabeth A. Kendzior, *University of Illinois.* F. J. King, *F.S.U.* David Klasson, *Millville, Calif.* Ken Kramer, *Wright State University.* Willian H. Long, *F.S.U.* Robert Lepper, *California State College.* Harold G. Liebherr, *Milwaukee, Wis.* William D. Larson, *College of St. Thomas.* Mable M. Lund, *Beaverton, Oregon.* H. D. Luttrell, *North Texas State University.* Maxwell Maddock, *F.S.U.* Solomon Malinsky, *Sarasota, Florida.* Eloise A. Mann, *Sarasota, Florida.* Harleen W. McAda, *University of California at Santa Barbara.* Auley A. McAuley, *Michigan State University.* E. Wesley McNair, *F.S.U.* Marilyn Miklos, *F.S.U.* Floyd V. Monaghan, *Michigan State University.* Rufus F. Morton, *Westport, Conn.* Tamson Myer, *F.S.U.* Gerald Neufeld, *F.S.U.* James Okey, *University of California.* Lawrence E. Oliver, *F.S.U.* Larry O'Rear, *Alice, Texas.* Herman Parker, *University of Virginia.* Harry A. Pearson, *Western Australia.* James E. Perham, *Randolph-Macon Woman's College.* Darrell G. Phillips, *University of Iowa.* Howard Pierce, *F.S.U.* David Poché, *F.S.U.* Charles O. Pollard, *Georgia Institute of Technology.* Glenn F. Powers, *Northeast Louisiana State College.* Ernest Gene Preston, *Louisville, Ky.* Edward Ramey, *F.S.U.* Earl R. Rich, *University of Miami.* John Schaff, *Syracuse University.* Carroll A. Scott, *Williamsburg, Iowa.* Earle S. Scott, *Ripon College.* Thomas R. Spalding, *F.S.U.* Michael E. Stuart, *University of Texas.* Sister Agnes Joseph Sun, *Marygrove College.* Clifford Swartz, *State University of New York.* Thomas Teates, *F.S.U.* Bill W. Tillery, *University of Wyoming.* Ronald Townsend, *University of Iowa.* Mordecai Treblow, *Bloomsburg State College.* Henry J. Triezenberg, *National Union of Christian Schools.* Paul A. Vestal, *Rollins College.* Robert L. Vickery, *Western Australia.* Frederick B. Voight, *F.S.U.* Claude A. Welch, *Macalester College.* Paul Westmeyer, *F.S.U.* Earl Williams, *University of Tampa.* G. R. Wilson, Jr., *University of South Alabama.* Harry K. Wong, *Atherton, California.* Charles M. Woolheater, *F.S.U.* Jay A. Young, *King's College.* Victor J. Young, *Queensborough Community College.*

The genesis of some of the ISCS material stems from a summer writing conference in 1964. The participants were:

Frances Abbott, *Miami-Dade Junior College.* Ronald Atwood, *University of Kentucky.* George Assousa, *Carnegie Institute.* Colin H. Barrow, *University of West Indies.* Peggy Bazzel, *F.S.U.* Robert Binger (deceased). Donald Bucklin, *University of Wisconsin.* Martha Duncan Camp, *F.S.U.* Roy Campbell, *Broward County Board of Public Instruction, Fla.* Bruce E. Cleare, *Tallahassee Junior College.* Ann-cile Hall, *Pensacola, Florida.* Charles Holcolmb, *Mississippi State College.* Robert Kemman, *Mt. Prospect, Ill.* Gregory O'Berry, *Coral Gables, Florida.* Elra Palmer, *Baltimore.* James Van Pierce, *Indiana University Southeast.* Guenter Schwarz, *F.S.U.* James E. Smeland, *F.S.U.* C. Richard Tillis, *Pine Jog Nature Center, Florida.* Peggy Wiegand, *Emory University.* Elizabeth Woodward, *Augusta College.* John Woolever, *Sarasota, Florida.*

Foreword

A pupil's experiences between the ages of 11 and 16 probably shape his ultimate view of science and of the natural world. During these years most youngsters become more adept at thinking conceptually. Since concepts are at the heart of science, this is the age at which most students first gain the ability to study science in a really organized way. Here, too, the commitment for or against science as an interest or a vocation is often made.

Paradoxically, the students at this critical age have been the ones least affected by the recent effort to produce new science instructional materials. Despite a number of commendable efforts to improve the situation, the middle years stand today as a comparatively weak link in science education between the rapidly changing elementary curriculum and the recently revitalized high school science courses. This volume and its accompanying materials represent one attempt to provide a sound approach to instruction for this relatively uncharted level.

At the outset the organizers of the ISCS Project decided that it would be shortsighted and unwise to try to fill the gap in middle school science education by simply writing another textbook. We chose instead to challenge some of the most firmly established concepts about how to teach and just what science material can and should be taught to adolescents. The ISCS staff have tended to mistrust what authorities believe about schools, teachers, children, and teaching until we have had the chance to test these assumptions in actual classrooms with real children. As conflicts have arisen, our policy has been to rely more upon what we saw happening in the schools than upon what authorities said could or would happen. It is largely because of this policy that the ISCS materials represent a substantial departure from the norm.

The primary difference between the ISCS program and more conventional approaches is the fact that it allows each student to travel at his own pace, and it permits the scope and sequence of instruction to vary with his interests, abilities, and background. The ISCS writers have systematically tried to give the student more of a role in deciding what he should study next and how soon he should study it. When the materials are used as intended, the ISCS teacher serves more as a "task easer" than a "task master." It is his job to help the student answer the questions that arise from his own study rather than to try to anticipate and package what the student needs to know.

There is nothing radically new in the ISCS approach to instruction. Outstanding teachers from Socrates to Mark Hopkins have stressed the need to personalize education. ISCS has tried to do something more than pay lip service to this goal. ISCS' major contribution has been to design a system whereby an average teacher, operating under normal constraints, in an ordinary classroom with ordinary children, can indeed give maximum attention to each student's progress.

The development of the ISCS material has been a group effort from the outset. It began in 1962, when outstanding educators met to decide what might be done to improve middle-grade science teaching. The recommendations of these conferences were converted into a tentative plan for a set of instructional materials by a small group of Florida State University faculty members. Small-scale writing sessions conducted on the Florida State campus during 1964 and 1965 resulted in pilot curriculum materials that were tested in selected Florida schools during the 1965-66 school year. All this preliminary work was supported by funds generously provided by The Florida State University.

In June of 1966, financial support was provided by the United States Office of Education, and the preliminary effort was formalized into the ISCS Project. Later, the National Science Foundation made several additional grants in support of the ISCS effort.

The first draft of these materials was produced in 1968, during a summer writing conference. The conferees were scientists, science educators, and junior high school teachers drawn from all over the United States. The original materials have been revised three times prior to their publication in this volume. More than 150 writers have contributed to the materials, and more than 180,000 children, in 46 states, have been involved in their field testing.

We sincerely hope that the teachers and students who will use this material will find that the great amount of time, money, and effort that has gone into its development has been worthwhile.

Tallahassee, Florida
February 1972

The Directors
INTERMEDIATE SCIENCE CURRICULUM STUDY

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Notes to the Student

The word *science* means a lot of things. All of the meanings are "right," but none are complete. *Science* is many things and is hard to describe in a few words.

We wrote this book to help you understand what science is and what scientists do. We have chosen to show you these things instead of describing them with words. The book describes a series of things for you to do and think about. We hope that what you do will help you learn a good deal about nature and that you will get a feel for how scientists tackle problems.

How is this book different from other textbooks?

This book is probably not like your other textbooks. To make any sense out of it, you must work with objects and substances. You should do the things described, think about them, and then answer any questions asked. Be sure you answer each question as you come to it.

The questions in the book are very important. They are asked for three reasons:

1. To help you to think through what you see and do.
2. To let you know whether or not you understand what you've done.
3. To give you a record of what you have done so that you can use it for review.

How will your class be organized?

Your science class will probably be quite different from your other classes. This book will let you start work with less help than usual from your teacher. You should begin each day's work where you left off the day before. Any equipment and supplies needed will be waiting for you.

Your teacher will not read to you or tell you the things that you are to learn. Instead, he will help you and your classmates individually.

Try to work ahead on your own. If you have trouble, first try to solve the problem for yourself. Don't ask your teacher for help until you really need it. Do not expect him to give you the answers to the questions in the book. Your teacher will try to help you find where and how you went wrong, but he will not do your work for you.

After a few days, some of your classmates will be ahead of you and others will not be as far along. This is the way the course is supposed to work. Remember, though, that there will be no prizes for finishing first. Work at whatever speed is best for you. *But be sure you understand what you have done before moving on.*

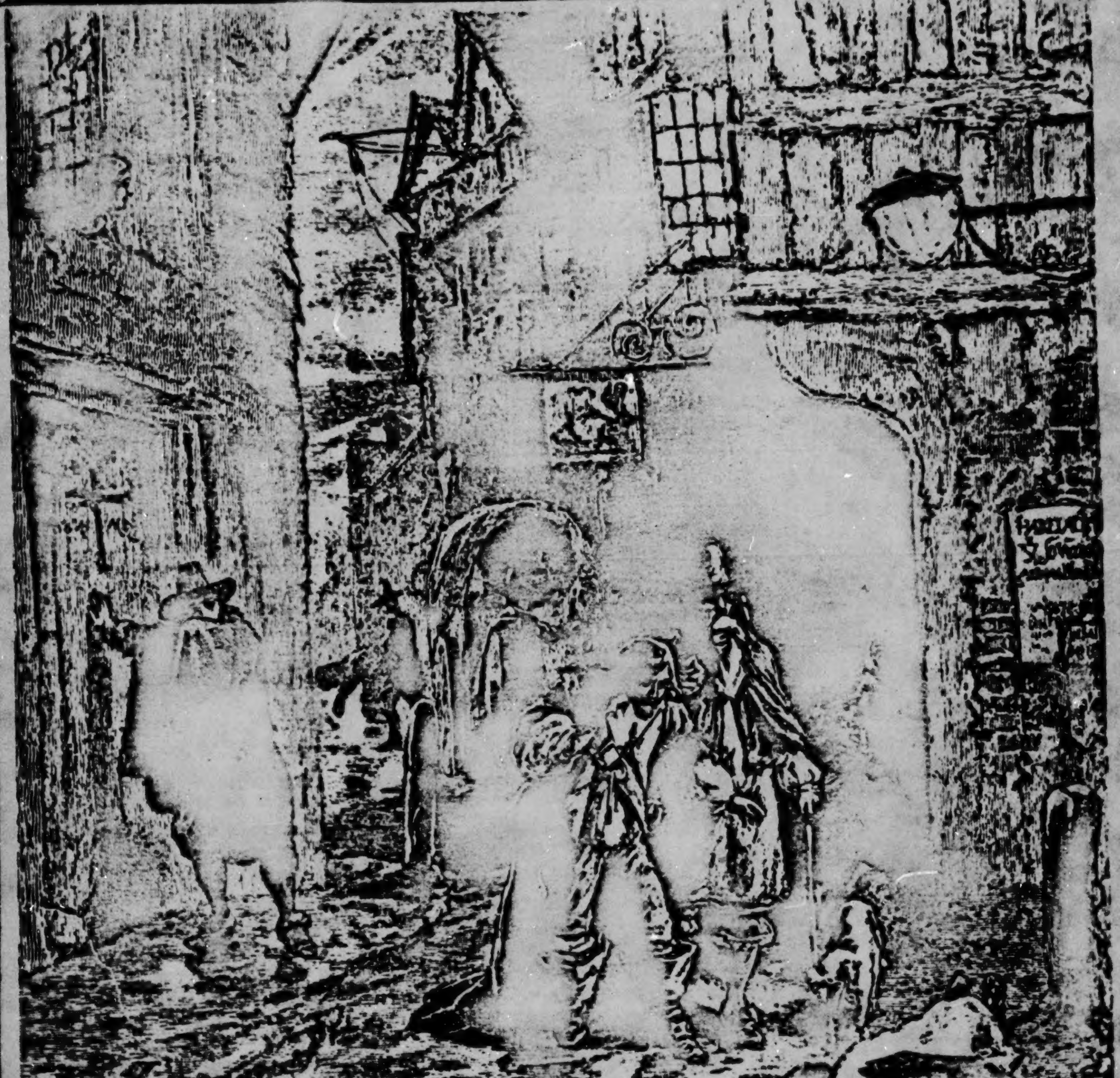
Excursions are mentioned at several places. These special activities are found at the back of the book. You may stop and do any excursion that looks interesting or any that you feel will help you. (Some excursions will help you do some of the activities in this book.) Sometimes, your teacher may ask you to do an excursion.

What am I expected to learn?

During the year, you will work very much as a scientist does. You should learn a lot of worthwhile information. More important, we hope that you will learn how to ask and answer questions about nature. *Keep in mind that learning how to find answers to questions is just as valuable as learning the answers themselves.*

Keep the big picture in mind, too. Each chapter builds on ideas already dealt with. These ideas add up to some of the simple but powerful concepts that are so important in science. If you are given a Student Record Book, do all your writing in it. *Do not write in this book.* Use your Record Book for making graphs, tables, and diagrams, too.

From time to time you may notice that your classmates have not always given the same answers that you did. This is no cause for worry. There are many right answers to some of the questions. And in some cases you may not be able to answer the questions. As a matter of fact, no one knows the answers to some of them. This may seem disappointing to you at first, but you will soon realize that there is much that science does not know. In this course, you will learn some of the things we don't know as well as what is known. Good luck!



EQUIPMENT LIST

None

CHAPTER EMPHASIS

Proper interaction between man and his environment is critical for survival.

Chapter 1

The Black Death

Excursion 1-1 is keyed to this chapter.

The Honorable Doctor Eric Robinson
Maleren Road, Staden isl.
Stockholm, Sweden *10 April, 1351*

We set sail from Naples, Italy, five days ago and are en route to Barcelona, Spain. Winds are light and the weather is good. So with time to spare, I shall undertake to keep my promise to you and put my log notes in some order. Perhaps then you may make some sense of the horrible pestilence that has demolished the people of Europe and stolen so many of our dearest ones.

When we reached Marseilles, France, over three years ago in late 1347, the plague had already arrived there. The people suspected it had come by ship from Genoa. The Genoan merchant marine may have brought the disease from Kaffa, a Genoan colony on the Black Sea. Kaffa had been besieged by the Tartars. But the Tartars were finally forced to give up the siege because so many of their forces were lost to the pestilence. Before they departed, the Tartars catapulted bodies of their dead warriors into the city, hoping to spread the death among the citizens. They believed the pestilence could be transmitted from the dead to the living.

It is believed that when the Genoan sailors returned home, they brought the disease with them. It is also rumored that in addition to the disease, they brought a large number of black rats that had stowed away while their ships had been docked at Kaffa. Upon reaching the port of Genoa, the disease and, of course, the rats spread into the city.

Soon the blight spread to Marseilles. No one knew how for sure, perhaps by ship again. Some said it was spread by

MAJOR POINTS

1. Human problems can be caused by misuse of the environment.
2. Each student should be led to face the following questions:
   a. How is a pollution problem defined?
   b. How do I contribute to the pollution problem?
   c. What can I do to help control pollution?

This chapter sets the stage for the whole unit. Because no equipment is used, students may underestimate its importance. You may want to have a short discussion, without preaching, pointing them in the direction of thinking for themselves.

the miasma, or poison cloud. Corrupted air, damp mists, hot south winds have all been suspected of carrying the pestilence. Earthquakes, fire pillars, and other mysterious occurrences are considered by some to be the cause of the plague. While in Venice, a few months ago, I heard that the Venetians had received an omen of the coming plague. Just before the disease appeared in the city, an earthquake occurred and the bells in St. Mark's rang out without being touched by human hands.

Astrologers in Paris blame the catastrophe on the conjunction of Saturn, Jupiter, and Mars in the house of Aquarius. Other Parisians believed the pestilence to have been caused by a ball of fire seen above the city.

I'm sure that you, with your scientific knowledge, will be able to decide which, if any, of these explanations is best. Whatever the cause, the people I've seen all around Europe seem resigned to their fate. They agree that the pestilence is the will of God. They are sure their sins have brought this punishment upon them.

As you know, millions have died in the three years since 1347. I need not report the horrible nature of the disease. You know it too well. But how it passes from person to person is still a mystery. Some say it is by breath; others claim only a look is necessary. Just by touch it spreads, according to one theory. Some even believe it is foul air bottled up in vessels. It is said that these vessels are carried by evil men to a place upwind from a city. Then their foul contents are released and the fumes spread over the town.

This letter describing the Black Death is used to get the students thinking about human problems. Don't let them get too concerned with the details of the letter. Some of the words may even be unfamiliar to them. Remember that they are reading a letter that supposedly was written more than 600 years ago, and that includes many misconceptions, superstitions, and prejudices of the 14th century.

It is almost unbelievable how many have died the horrible death of bursting boils and blistering fever. No one is certain of the count. It is estimated that, within six months, Florence lost 55,000 of its 90,000 inhabitants. The reports I have heard from all over Italy suggest that up to 60% of the population perished. Apparently, the same horror abounded in other countries. All in all, more than 30% of the population of Europe have died. The heaviest toll reported is among the clergy—around 50%. Some monasteries have been completely wiped out.

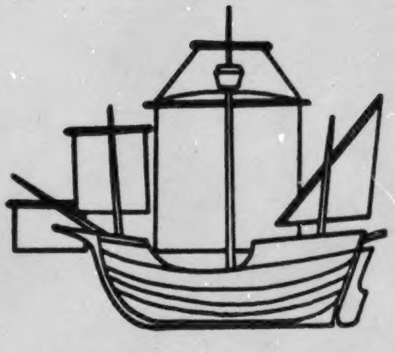
But my promise was to help you chart the spread of the plague. I have tabulated what figures I could get in the enclosed logs. All dates are approximate. The cities have been *identified according to the six-month period during which the disease fell upon the inhabitants. I trust this will help you in your research.*

May God live with you each day.
Your friend and brother,

Swen

The plague described briefly in this letter is perhaps the greatest environmental crisis ever to strike Europe. Later to be called the Black Death, it originated in Asia. It was not the only plague to strike. There were many before and several to follow. However, the Black Death of the fourteenth century took a dreadful toll. Nearly thirty million Europeans died.

The log referred to in the letter follows in Table 1-1. Assume that you are the physician receiving these data. Use the data to chart the movement of the Black Death across Europe. (The names used in the log, as well as many in the letter, have been modernized so that they are the ones most familiar to you.)



As a suggestion, you may want to have all students number the seven date blocks in Table 1-1 from 1 through 7. Then they number the cities in each block with the corresponding number. For instance, the December 1347 block would be labeled "1." Then Genoa, Marseilles, Messina, Naples, and Rome would be labeled "1" on the map. All cities numbered the same would be connected with a smooth line. The different lines could be drawn in different colors or as different types of lines (dashed, solid, etc.).

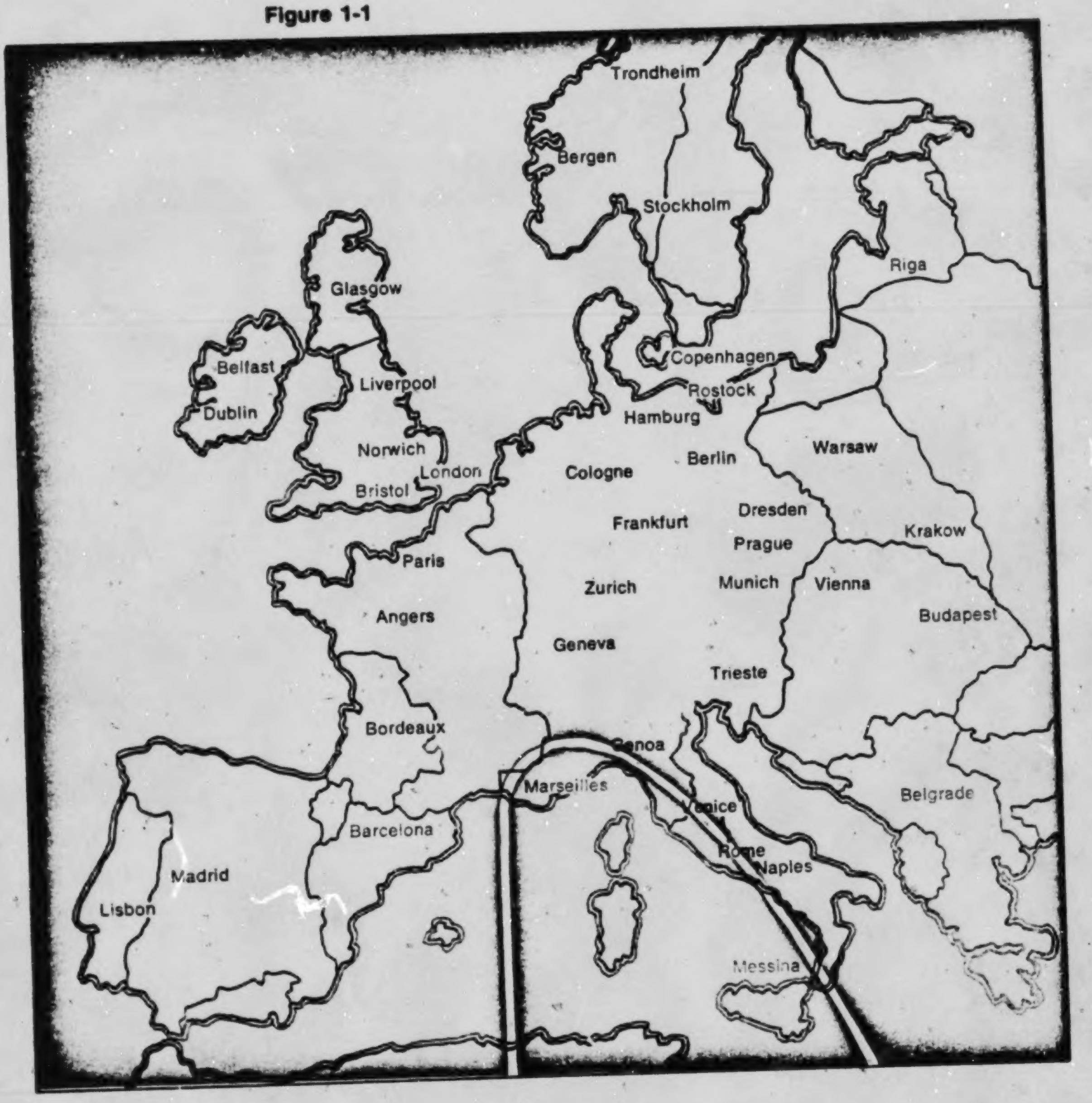
Table 1-1

Month and Year	New Cities Affected	Month and Year	New Cities Affected
December, 1347	Genoa, Marseilles, Messina, Naples, Rome	December, 1349	Belfast, Bergen, Berlin, Dresden, Glasgow, Hamburg
June, 1348	Angers, Belgrade, Bordeaux, Geneva, Madrid, Paris, Trieste, Venice	June, 1350	North of Bergen, Copenhagen, Rostock, Warsaw
December, 1348	Bristol, Budapest, Lisbon, London, Munich, Vienna, Zurich	December, 1350	South of Riga, Stockholm, North of Trondheim
June, 1349	Cologne, Dublin, Frankfurt, Liverpool, Krakow, Norwich, Prague		

1-1. You may have to help some students in drawing a best-fit (smooth) line on the map. If done correctly, the series of lines will look like a wave moving across Europe.

☐**1-1.** For each six-month interval, show how far the plague had spread by sketching a line of best fit across the map in Figure 1-1 of your Record Book. (Notice that a line has already been drawn for the December 1347 information.)

Figure 1-1

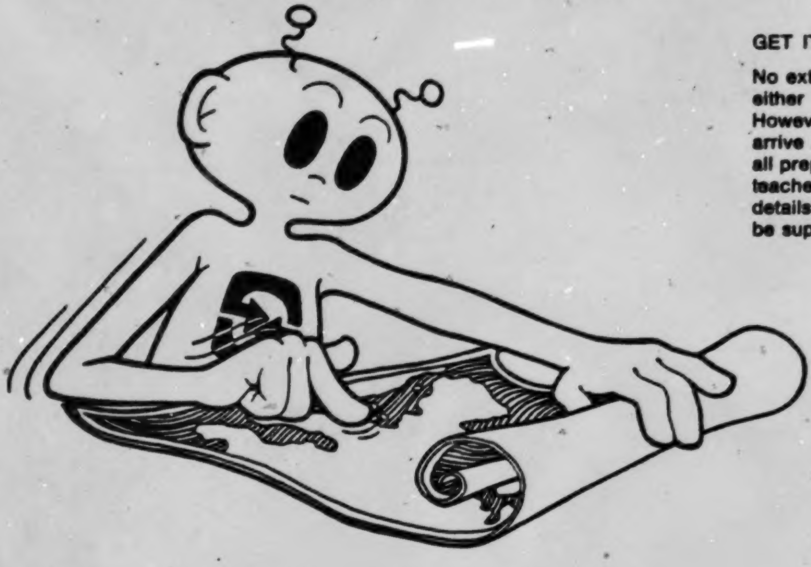

Trondheim
Bergen
Stockholm
Riga
Glasgow
Copenhagen
Belfast
Liverpool
Rostock
Dublin
Hamburg
Norwich
Berlin
Warsaw
London
Cologne
Bristol
Dresden
Frankfurt
Krakow
Prague
Paris
Zurich
Munich
Vienna
Budapest
Angers
Geneva
Trieste
Bordeaux
Genoa
Marseilles
Belgrade
Venice
Barcelona
Rome
Naples
Madrid
Lisbon
Messina

The steady march of the plague across Europe represented a great catastrophe for the people. Many countries were overpopulated, and great crop failures had brought these nations to their knees. Now a killing blow was dealt by disease. The suffering people believed their folly and sin had brought disaster down upon them. And they were not entirely wrong. Overpopulation in certain areas had produced overcrowded and unhealthy living conditions. Careless piling of rubbish provided food for increasing numbers of rats and other vermin. The people had misused their environment. They did not understand that the environment cannot be misused indefinitely.

Since the fourteenth century, man has learned to control the spread of the plague by using special drugs and vaccines. However, man has much to learn about his environment. He is just beginning to see that his living habits can make this world unsafe and unfit for life. This unit, *Environmental Science*, can help you better understand how your actions influence the world in which you live.

If you'd like to find out more about the cause and effects of the Black Death, do **Excursion 1-1**, "A Real Killer." It's a good chance to see if you remember how to plot data on a grid and how to read the graph, too.

Before going on, do Self-Evaluation 1 in your Record Book.



You may want to engage in discussion with individuals or small groups on the information that can be read from the completed map exercise. What direction did the wave seem to be headed? Where did it seem to originate? Did it seem to travel at a uniform speed? What might have speeded it up or slowed it down?

Excursion 1-1 will probably be done by most students. It is general in nature.

EXCURSION

GET IT READY NOW FOR CHAPTER 2.

No extensive preparations are necessary for either the chapter or the excursions. However, the goldfish for Chapter 5 may arrive at any time, and you should complete all preparations as soon as possible. See the teacher notes at the end of Chapter 4 for details. Friction matches for Chapter 2 must be supplied locally.

EQUIPMENT LIST

Per student-team

1 friction match
1 piece of sandpaper
1 lump of modeling clay

Chapter 2

Can You Match It?

Excursions 2-1 and 2-2 are keyed to this chapter.

Most people believe they have little if any effect on what happens in their surroundings. They think they have no influence on anything. Are these people right, or wrong? You can see for yourself. From the supply table, get the following:

1 friction match
1 small piece of sandpaper
1 lump of clay

In a few minutes, you will observe the match as it burns. But first, you should prepare for your observations.

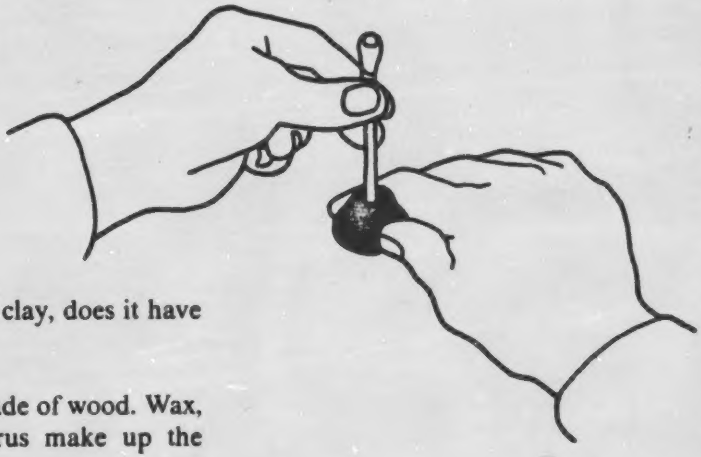
ACTIVITY 2-1. Stand the match in the lump of clay. Take a close look at it even though you have seen matches many times.

CHAPTER EMPHASIS

Organisms influence other organisms in their environment.

MAJOR POINTS

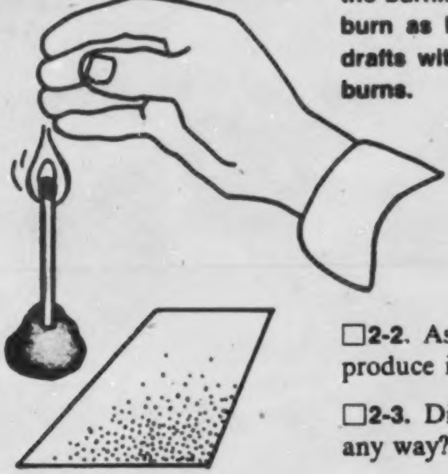
1. An object or an individual can affect its environment by taking something away or by adding something to the surroundings.
2. A simple thing like a burning match involves a chemical reaction that changes its surroundings.
3. A system is a set of things that influence each other; the things that make up a system are called components.
4. The output of one component of a system may be the input for another component of the system.
5. All living or nonliving things influence the surroundings just by being there.
6. The total effect of many living or nonliving things can be disastrous.
7. Through photosynthesis, green plants take carbon dioxide and some oxygen from the air and release a greater amount of oxygen to the air.
8. Living things that can take energy directly from the sun and store it as chemical energy in their bodies are called *producers*.
9. Living things that depend on other living things for energy are called *consumers*.
10. Organisms that produce chemical changes in waste materials so that the products can be used by other living things are called *decomposers*.
11. If the environmental input-output balance is upset, drastic results may occur.



☐**2-1.** As the match stands in the lump of clay, does it have any effect on its surroundings?

The stick part of the friction match is made of wood. Wax, potassium chlorate, sulfur, and phosphorus make up the head.

ACTIVITY 2-2. Strike the match on the sandpaper and stand the burning match once more in the lump of clay. Allow it to burn as long as possible. You may need to shield it from drafts with your hand or a book. Observe it carefully as it burns.



☐**2-2.** As the match burned, what changes, if any, did it produce in the surroundings?

☐**2-3.** Did any of the changes you observed affect you in any way?

The burning of a match is a very common occurrence. It may appear to be unimportant, but is it really? Suppose you look at it from a chemist's point of view.

2-4. Possible answers may be that
(a) heat and light were produced,
(b) material disappeared, or
(c) new substances were produced.

☐**2-4.** What evidence do you have that chemical changes were taking place as the match burned?

If you had trouble with question 2-4, it may be because you don't recall what is meant by "chemical change." The following Checkup will help you decide whether you need to study this idea before going ahead.

CHECKUP

In your Record Book, place a check by the letter of each statement that is correct.

1. During a chemical change,
   - **a.** starting materials called reactants are changed to new substances called products.
   - **b.** energy changes occur.
   - **c.** temperature and concentration of reactants can affect the rate of change.
   - **d.** a gas is always formed.
2. The ISCS particle model for matter includes the idea that

- **a.** all matter is composed of particles called atoms.
- **b.** there are about 1,000 different kinds of atoms.
- **c.** atoms may combine with each other and be held together by electrical forces.
- **d.** neutral combinations of two or more atoms contain equal amounts of positive and negative charge.

3. As a chemical reaction occurs,
- **a.** atoms in reactants are destroyed.
- **b.** reactant atoms are rearranged into new combinations called products.
- **c.** energy is needed to overcome the forces holding reactant atoms together.

Excursion 2-1 is a good remedial-review exercise on the particle model for matter. The checkup is the mechanism for getting those who need help into the excursion.

Turn to page 99 in **Excursion 2-1** to check your answers.

◀EXCURSION

☐**2-5.** Recall the procedure you used when lighting the match. What did you have to do?

As you know, the name given to the match you used is "friction match." If you remember your early work in ISCS, you know something about friction.

☐**2-6.** What form of energy is associated with friction?

To get your match started, you had to warm it up. You did this by striking (rubbing) it against a rough surface. This friction produced heat. All the match needed was heat and the oxygen in the surrounding air to get started.

☐**2-7.** What *products* resulted from the burning of the match?

2-7. Some students may indicate that carbon dioxide, among other products, was produced. Others may not be aware of this. This point is brought out on the next page.

Suppose the entire match burned. A chemist's simple statement about the chemical change you've observed might be this:

MATCH + AIR + HEAT → ASH + SMOKE + ENERGY

You supply heat by rubbing the match on the sandpaper. The heated substances in the match head combine with oxygen from the air to form new products. For example:

Phosphorus + Oxygen → Phosphorus oxide

Sulfur + Oxygen → Sulfur oxide

The ash that is produced during the burning is composed mostly of carbon and other unburned solids. The ash is the remains of the match. The smoke is a combination of gases and very tiny particles of solids carried up by the hot gases. One of the gases produced is carbon dioxide, a substance you know a lot about if you studied Volume 2 of ISCS. The wax and wood of the match contain hydrogen, in addition to carbon.

☐**2-8.** When hydrogen (H) combines with oxygen (O), what product is formed?

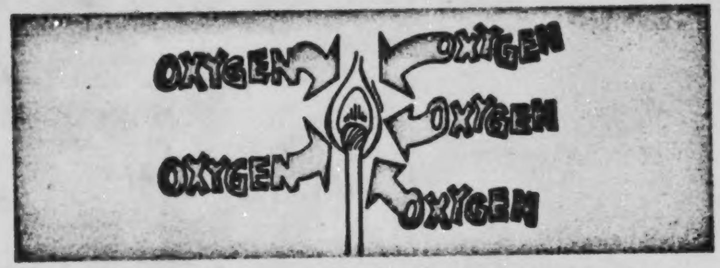
☐**2-9.** A very important product of the burning is energy. What forms of energy did you observe during the burning?

2-9. The student should be able to observe heat and light as forms of energy. From his knowledge of chemical reactions and burning, he may infer that chemical energy was involved.

You can see that when a simple match burns, some very complicated things happen. In fact, a complete description of all the changes would be very complicated indeed. However, the important thing is the fact that the burning match changes its own surroundings. It does this in two basic ways.

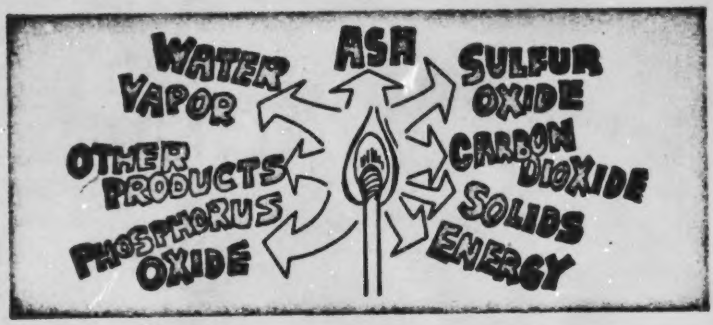
First, the burning match takes something away from its surroundings.

Figure 2-1



And second, the burning match adds things to its surroundings.

Figure 2-2



It helps to think of the match and the surrounding air as a system. You may recall that a *system* is a set of things that influence each other. In other words, a system is a set of things that have some effect on each other.

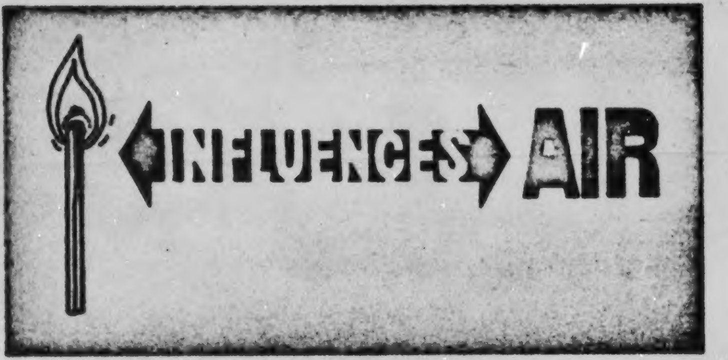


Figure 2-3

The things that make up a system are called *components.* The match and the surrounding air may be thought of as the components of a system. Figure 2-4 illustrates what happens in this system as the match burns.

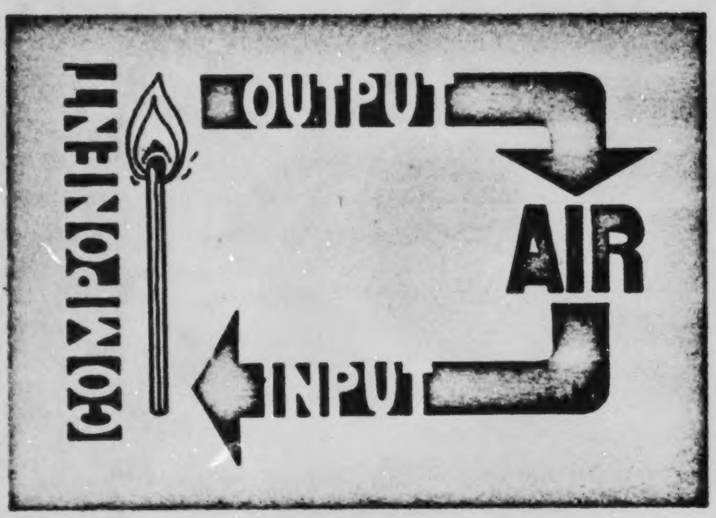


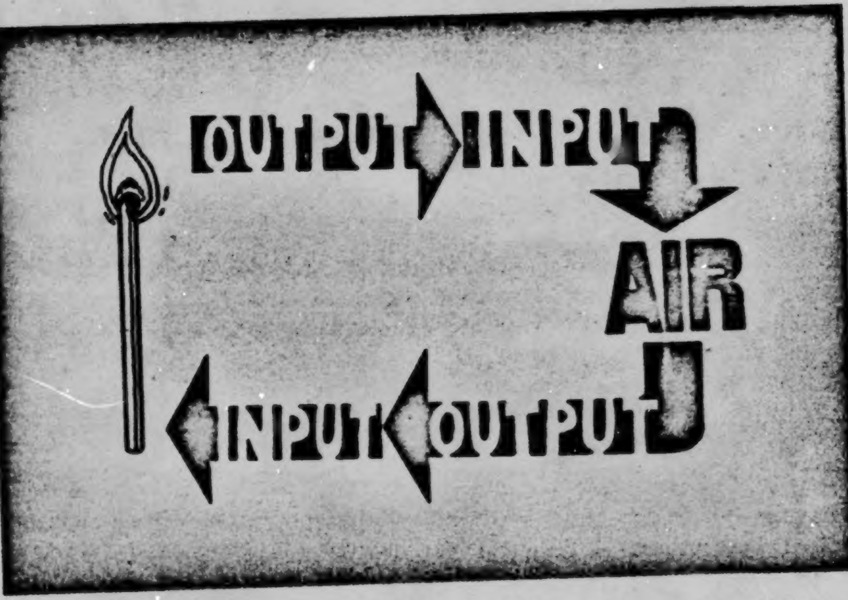
Figure 2-4

As the match burns, it releases certain products into the air. These products are its output.

☐**2-10.** What is the input to the match from the air?

The match's total output includes all the products it gives to its surroundings. Most of the match's output goes into the surrounding air. This output of heat, gases, and solid particles changes the surrounding air. The air's input of oxygen to the match is necessary for it to burn. This input causes great changes in the match. Figure 2-5 illustrates the idea that output for one component is input for the other.

Figure 2-5



In the first paragraph of this chapter, you were told that most people believe they have no important influence on their surroundings. Your activities have shown that something as simple as a friction match can change its own environment and, in turn, be changed itself. Do people match up? Do the effects of people and other living things on their surroundings compare to those of a burning match?

☐**2-11.** Are you having any influence at this moment on your surroundings?

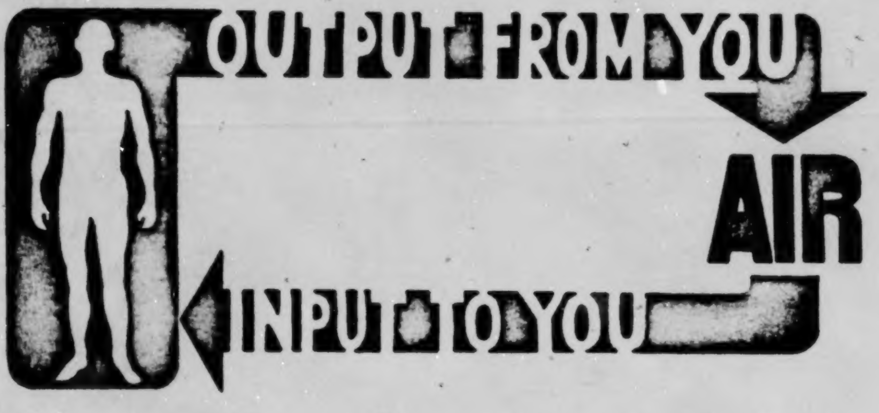
2-11. This question points up for the student one of the key ideas of environmental science. Answers will vary, but most students should be able to see that they are removing oxygen from the air and adding carbon dioxide and water vapor to the air. In addition, the student is causing air to move, and is heating it. Moreover, he is influencing his surroundings just by being there, taking up space.

Think of yourself and the surrounding air as components of a system. Remember that components influence each other. Figure 2-6 of your Record Book suggests that an input-output exchange is occurring between you and the air right now.

☐**2-12.** In Figure 2-6 of your Record Book, list under the proper heading those things being exchanged between you and the air. Then have your teacher check your work before going ahead.

2-12. Note the instructions for your check before the student proceeds. You may want to initial a book when you check it.

Figure 2-6



As you take in oxygen from the air and release CO_2 and heat, you produce important changes in your surroundings. You increase the temperature. You increase the amount of CO_2 in the air around you, and you decrease the amount of oxygen. These changes occur even when you sit quietly. You really do influence your surroundings. But how can one person's effect be important?

☐**2-13.** Suppose everyone in your room struck one match at the same time. Would the heat, smoke, and odor produced make a noticeable change in the room?

The small effect that each person has on changing the surroundings may at first seem unimportant, just as the effect of one match seems so small. But combining many small effects can produce great changes in the environment. One person all alone may have little effect on his world. But the total effects of many persons living close together can be disastrous for their surroundings.

Living things have an important effect on their surroundings. All creatures and plants have a set of input-output needs. Each one must take in certain solids, liquids, and gases. And each one must have the energy it needs to change these raw materials into chemicals its body can use.

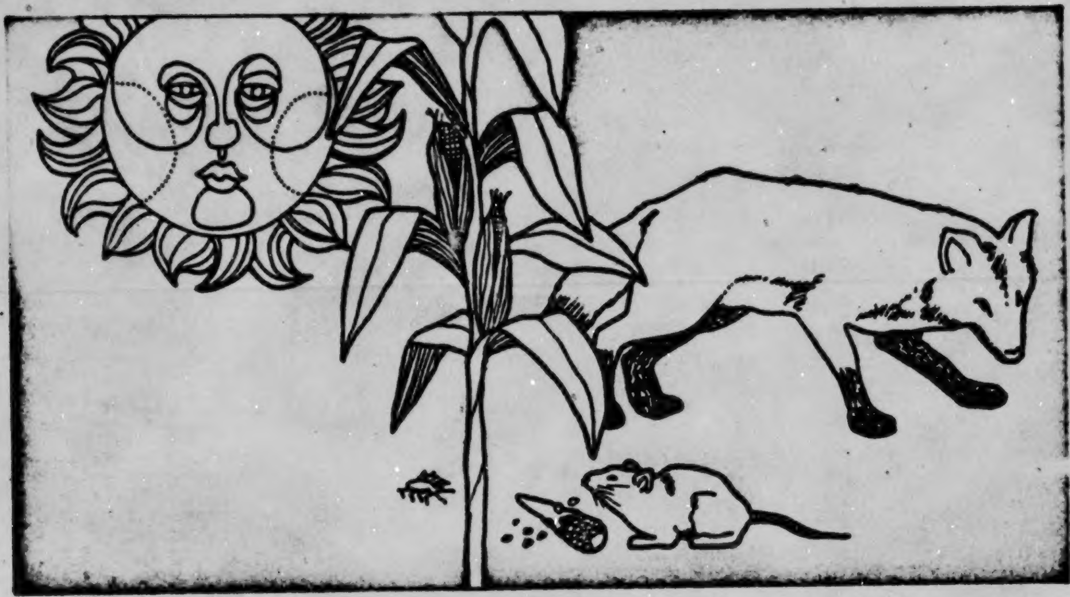


Figure 2-7

☐**2-14.** In your Record Book, list the things that each of the living organisms shown in Figure 2-7 must take from its surroundings in order to survive.

2-14 and 2-15. These are leading questions. Some students may know that, along with other things, plants take in carbon dioxide and give out oxygen. Animals take in oxygen and give out carbon dioxide. The next several pages will go into this more thoroughly.

Corn Plant Rat "Bug" Fox

☐**2-15.** What output products would you predict for each living organism in Figure 2-7?

Corn Plant Rat "Bug" Fox

Each of the organisms in Figure 2-7 needs to take in air, water, and certain solid substances from its surroundings. The solids taken in by the plant are usually dissolved in the water that comes in through the plant roots. Each of the organisms also produces certain waste products, which are output to the surroundings. These wastes result from the chemical changes occurring within the organisms. The combined activities of living organisms change the environment. These changes in the environment have their effect on the living things. This constant interaction of environment and the life it contains is illustrated in Figure 2-8.

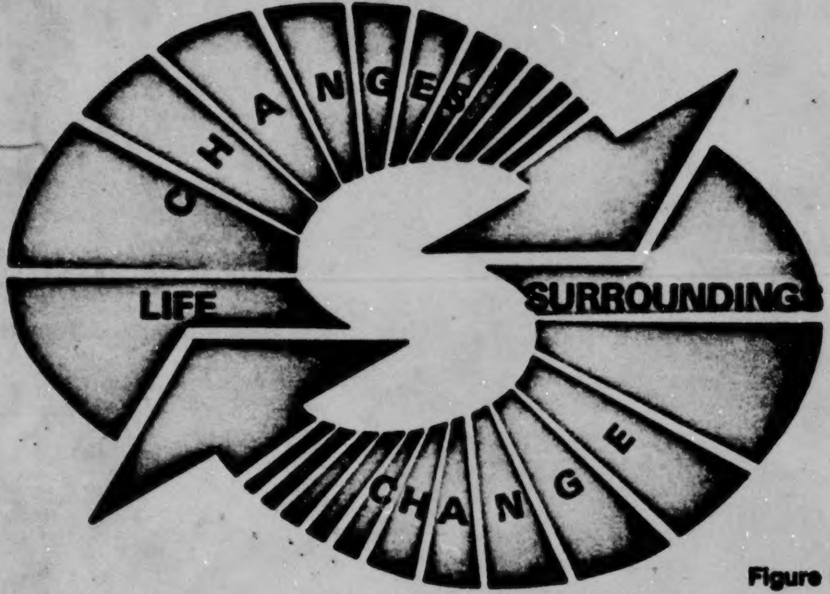
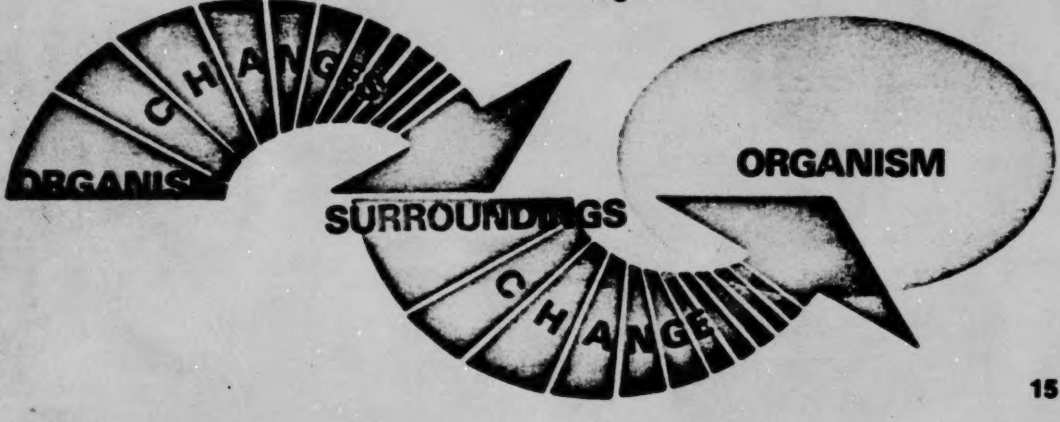

CHANGES
LIFE
SURROUNDINGS
CHANGE

Figure 2-8

Living organisms affect each other, too. These effects may be indirect, or they may be direct. If one animal eats another, he is certainly having a direct effect on that animal. Indirect effects between living things are usually not so obvious. They generally involve input-output exchanges between some organism and its surroundings. The resulting changes in the surroundings then affect some other organism. Thus the influence of one organism on the other is indirect. See Figure 2-9.

Figure 2-9


CHANGES
ORGANISM
SURROUNDINGS
CHANGE
ORGANISM

2-16. Direct effects might include the following: rat eats the corn, fox eats the rat, corn shades or hides both the rat and the fox.

2-17. Indirect effects might include these: corn replenishes oxygen in the air for the rat and fox; carbon dioxide from the rat and fox is used by the corn; waste products from the rat and fox fertilize the corn.

Don't try to teach the complicated process of photosynthesis to the student. The important thing for the student to see is the gross input-output system of the green plant without focusing on details at this point.

☐**2-16.** What direct effects do you suspect the living things in Figure 2-7 have on each other?

☐**2-17.** What indirect effects do you suspect the organisms in Figure 2-7 have on each other?

Look at a specific example of a very important indirect influence of one group of organisms on another. In addition to supplying a source of solid food for some animals, green plants also increase the amount of oxygen in the air. When light shines on them, a series of complicated chemical changes occurs within green plants. This series of chemical changes is called *photosynthesis.* During photosynthesis, air and water are taken in by the plant. Some oxygen and a lot of carbon dioxide are removed from the air and used by the plant to supply its own needs. While photosynthesis is occurring, the plant produces more oxygen than it uses. This excess is released to the atmosphere.

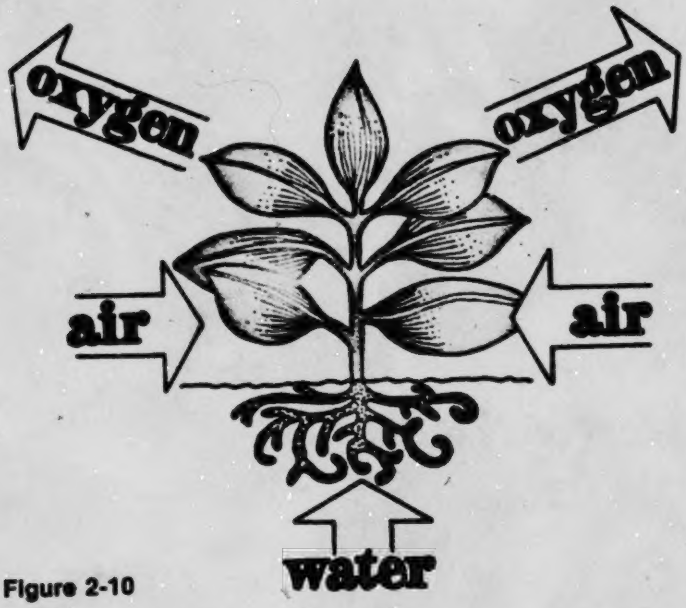


Figure 2-10

☐**2-18.** During photosynthesis, the output of green plants increases the amount of what gas in the surroundings?

☐**2-19.** During photosynthesis, the intake of green plants decreases the amount of what gas in the surrounding air?

☐**2-20.** Complete the diagram in Figure 2-11 of your Record Book by indicating the input-output gases exchanged between green plants, animals, and the atmosphere.

2-20. Strictly speaking, animals and plants both take in air from the atmosphere. They both use the components that they need from this air. Animals then give out a larger amount of carbon dioxide, and plants a larger amount of oxygen, than they took in.

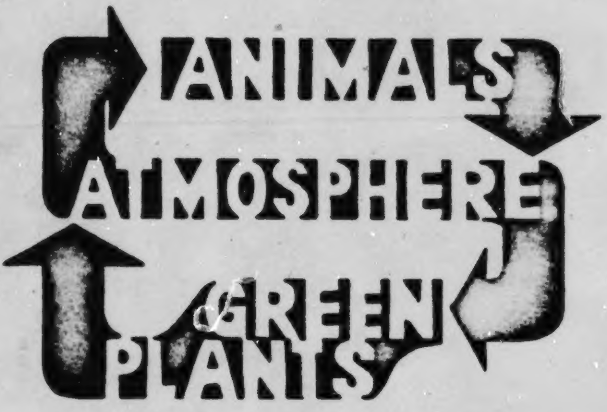


Figure 2-11

The indirect effect described in Figure 2-11 is very important. Animals take oxygen from the atmosphere and release CO_2. Plants take CO_2 and some oxygen from the atmosphere and release large amounts of oxygen. Each kind of living organism (green plants and animals) helps supply the needs of the other. The output of one becomes the input for the other, and the system is in balance.

☐**2-21.** What would happen to the surrounding atmosphere if all green plants were suddenly destroyed?

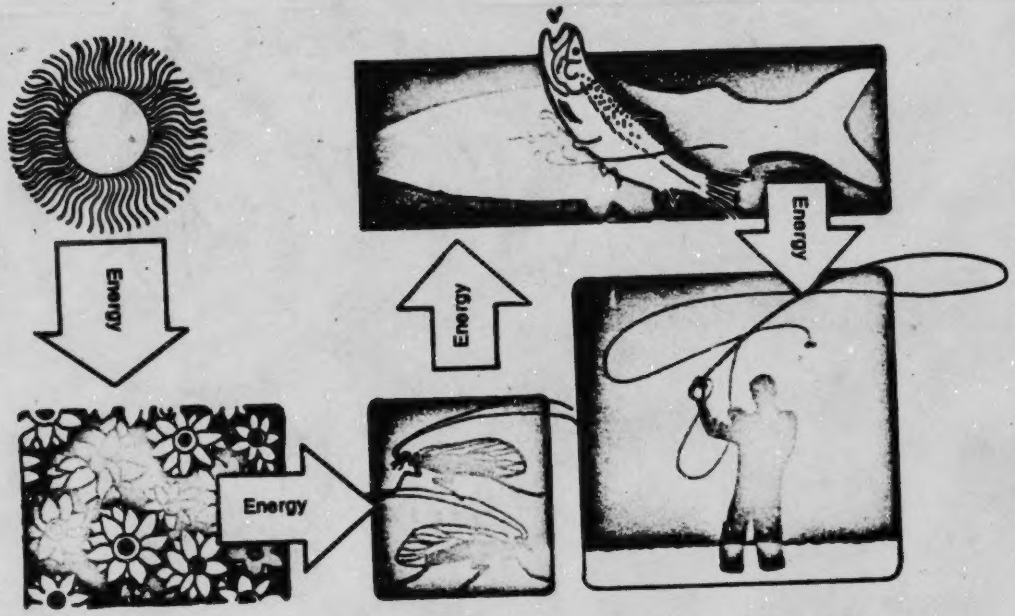
☐**2-22.** What would happen to the surrounding atmosphere if the number of animals needing oxygen were suddenly increased greatly?

2-21. The answer most likely is that the carbon dioxide in the atmosphere would increase and the oxygen decrease. Not so evident, and not to be expected from the student, are the effects on water vapor and the meteorological factors of temperature modification and dust storms.

As mentioned earlier, all living things must have energy to change the raw materials they consume into chemicals their bodies can use. Green plants get their energy directly from the sun. Through the process of photosynthesis, green plants are able to trap light energy from the sun. This energy is used by the plant to build the chemicals needed for growth. These chemicals store some of the energy that came originally from the sun. Because green plants are able to take energy directly from the sun and store it in the chemicals of their bodies, they are called *producers*.

Most animals cannot get the energy they need directly from the sun. They cannot carry out the process of photosynthesis. Animals must depend on getting the sun's energy in one of two indirect ways. They can eat green plants, or they can eat other animals that eat plants. Animals are called *consumers.*

Figure 2-12



☐**2-23.** The output of plants (oxygen) and the plants themselves benefit animals. What output of animals can be of benefit to green plants?

In addition to the CO_2 they release, the waste products of the animals and their bodies when they die are beneficial to plants. But if plants are to be able to use these waste products, another kind of organism must be involved. Microscopic organisms—mostly bacteria—in the soil and in the air can produce chemical changes in the waste materials and dead bodies of animals and plants. The products of these chemical changes can then be used by living plants. The microscopic organisms, as a group, are known as *decomposers.*

☐**2-24.** In your Record Book, sketch an input-output diagram in which you illustrate how the components in the

2-24. If students have difficulty with this input-output diagram, refer them back to the earlier examples (Figures 2-12, 2-11, 2-5). It may help to have them look at two components at a time, then another two, etc. For instance, what relationships are there between producers and surroundings? between producers and consumers? between surroundings and decomposers?

system shown in Figure 2-13 influence each other. Show all the input-output relationships you can think of. Remember, these relationships may be direct, or they may be indirect.

Each living thing affects its environment and thereby other living things. If input-output effects are in balance, the environment is safe from damaging change. But if for some reason the input-output balance is upset, drastic results may occur.

☐**2-25.** What do you predict would happen if all plant consumers in an area were suddenly killed?

☐**2-26.** What would be likely to be the result of poisoning all the decomposers in a given area?

☐**2-27.** What would be the effect, in a given area, of a sudden increase in animals that consumed other animals?

Man has affected the relationships between many of the organisms in his environment. Sometimes he has done this accidentally. At other times he has purposely tried to change natural balances. If you would like to learn more about one such attempt, turn to **Excursion 2-2,** "Bounty Hunters."

At the beginning of this chapter, you saw how even small changes in the environment are important. They add up to large effects. The effects of your own personal activities, though they may seem small, are really quite important. The living and nonliving world depends on an input-output balance. Man's activities can either keep or destroy that balance. Keeping things in balance is a tough job. Your activities are part of man's total effect on the environment. Therefore you must accept part of the responsibility for keeping things in balance. The following chapters will help you see what kinds of problems you and your surroundings face.

Before going on, do Self-Evaluation 2 in your Record Book.

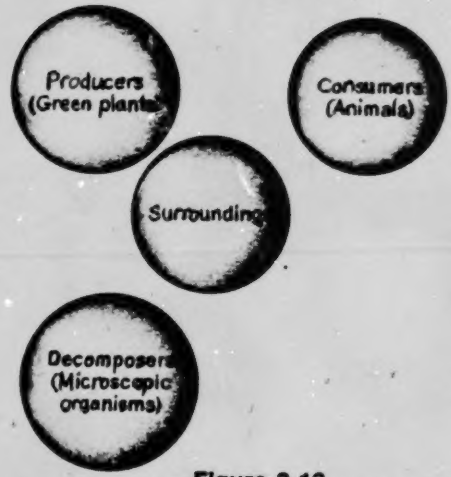


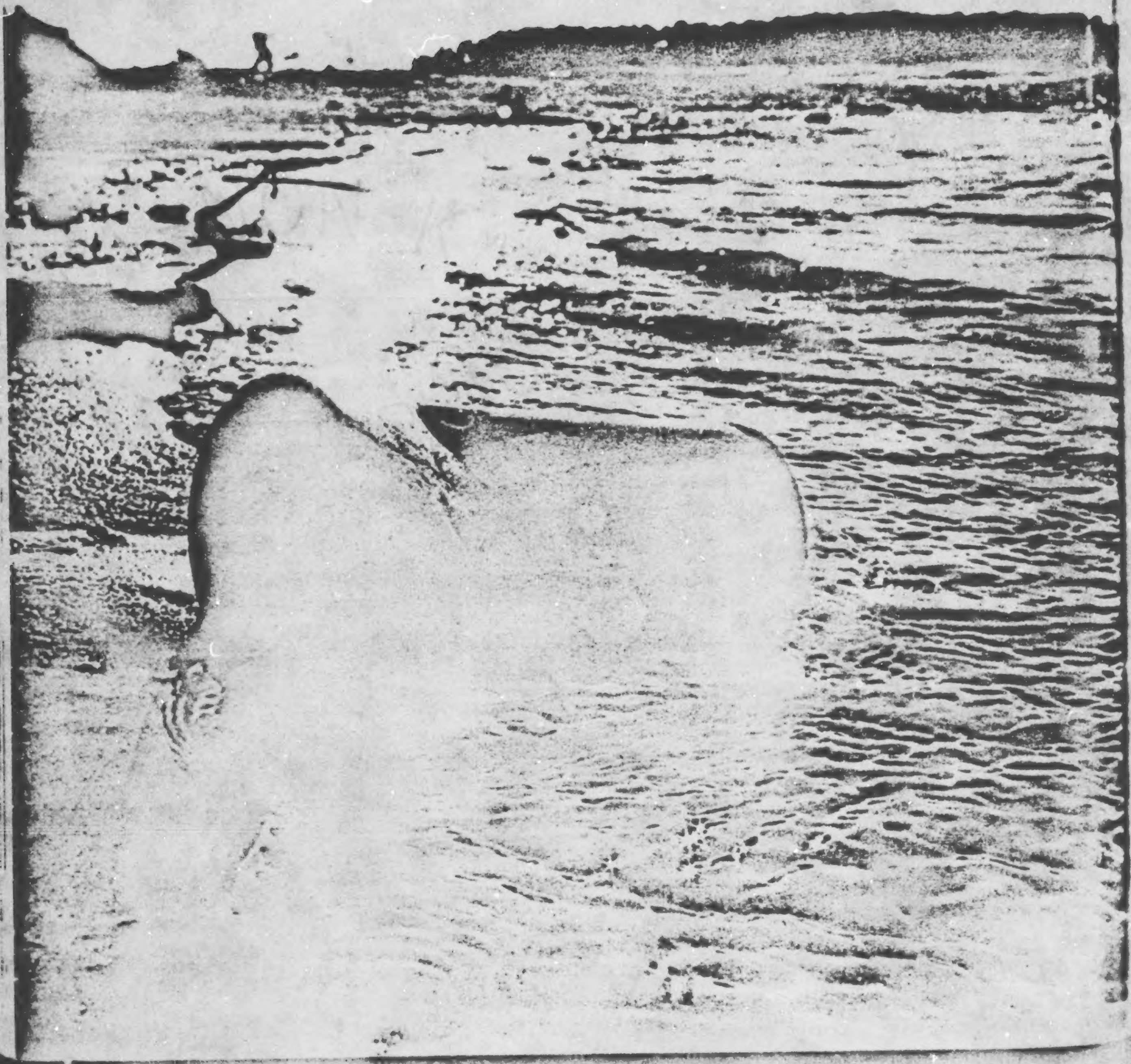
Figure 2-13

Excursion 2-2 is for general use. It examines one of man's attempts to affect the environment for his own benefit. Some students may have difficulty with the mathematics involved.

◀EXCURSION

GET IT READY NOW FOR CHAPTER 3

Each student or student-team will need a number of items that are listed at the beginning of the chapter. Among them are baby-food jars, which must be supplied locally. If you have not built up a supply from your students, do so now. You will also need test-tube racks, which can be made from wax-coated milk cartons or shoe boxes. Students will need a timing device if your room does not have a wall clock. You need to prepare the methylene blue indicator solution as follows: add 0.1 gram of methylene blue crystals to 500 ml of water. If you do not have a centigram balance, you will have to measure 1 gram and visually take $\frac{1}{10}$ of it. Don't make the solution any more concentrated: it will increase the length of time for reactions to occur.



EQUIPMENT LIST

Per student-team

- 1 plastic spoon
- 2 baby-food jars
- 1 teaspoon of powdered milk
- 1 teaspoon of dry yeast
- 2 5-ml air pistons
- 1 stirring rod
- 3 test tubes, 13 × 100 mm
- 1 test-tube rack
- Watch or clock

Per class

- 100 ml of methylene blue solution in dropper bottles
- Test-tube brushes
- Wax marking pencils

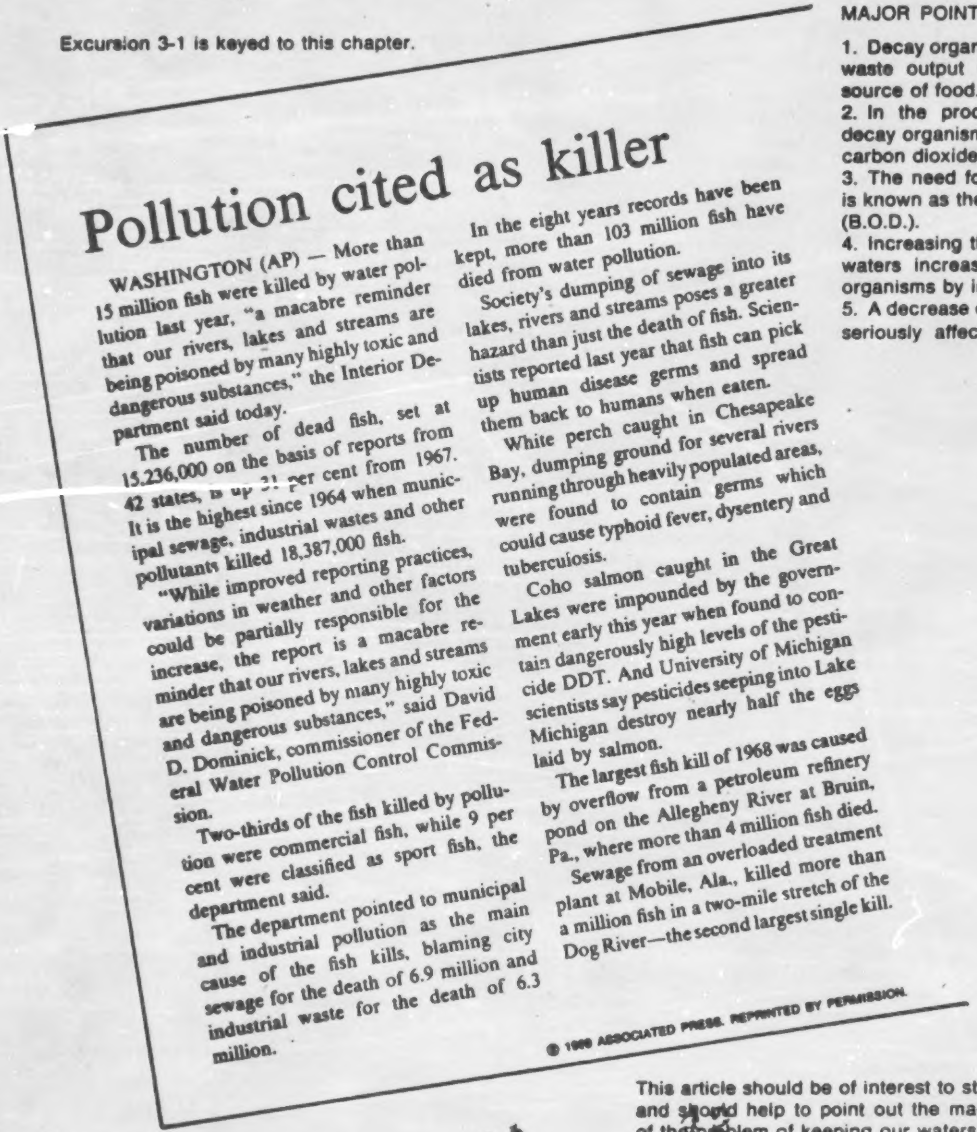
CHAPTER EMPHASIS

Pollution of water by sewage affects the amount of dissolved oxygen in the water and, in turn, affects organisms living in the water.

Water, Water Everywhere . . . But . . .

Chapter 3

Excursion 3-1 is keyed to this chapter.



Pollution cited as killer

WASHINGTON (AP) — More than 15 million fish were killed by water pollution last year, "a macabre reminder that our rivers, lakes and streams are being poisoned by many highly toxic and dangerous substances," the Interior Department said today.

The number of dead fish, set at 15,236,000 on the basis of reports from 42 states, is up 31 per cent from 1967. It is the highest since 1964 when municipal sewage, industrial wastes and other pollutants killed 18,387,000 fish.

"While improved reporting practices, variations in weather and other factors could be partially responsible for the increase, the report is a macabre reminder that our rivers, lakes and streams are being poisoned by many highly toxic and dangerous substances," said David D. Dominick, commissioner of the Federal Water Pollution Control Commission.

Two-thirds of the fish killed by pollution were commercial fish, while 9 per cent were classified as sport fish, the department said.

The department pointed to municipal and industrial pollution as the main cause of the fish kills, blaming city sewage for the death of 6.9 million and industrial waste for the death of 6.3 million.

In the eight years records have been kept, more than 103 million fish have died from water pollution.

Society's dumping of sewage into its lakes, rivers and streams poses a greater hazard than just the death of fish. Scientists reported last year that fish can pick up human disease germs and spread them back to humans when eaten.

White perch caught in Chesapeake Bay, dumping ground for several rivers running through heavily populated areas, were found to contain germs which could cause typhoid fever, dysentery and tuberculosis.

Coho salmon caught in the Great Lakes were impounded by the government early this year when found to contain dangerously high levels of the pesticide DDT. And University of Michigan scientists say pesticides seeping into Lake Michigan destroy nearly half the eggs laid by salmon.

The largest fish kill of 1968 was caused by overflow from a petroleum refinery pond on the Allegheny River at Bruin, Pa., where more than 4 million fish died.

Sewage from an overloaded treatment plant at Mobile, Ala., killed more than a million fish in a two-mile stretch of the Dog River—the second largest single kill.

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MAJOR POINTS

1. Decay organisms use the dead bodies and waste output of other organisms as their source of food.
2. In the process of decomposing waste, decay organisms take in oxygen and release carbon dioxide.
3. The need for oxygen by living organisms is known as the biochemical oxygen demand (B.O.D.).
4. Increasing the input of sewage in surface waters increases the B.O.D. of the decay organisms by increasing their population.
5. A decrease of oxygen in surface water can seriously affect living things in the water.

This article should be of interest to students, and should help to point out the magnitude of the problem of keeping our waters free of pollution.

Note that the student is being encouraged to use the systems approach from Chapter 2 in studying the input-output systems of lakes, streams, and rivers.

In this chapter and the next two, you will investigate some important changes that are taking place in our lakes, streams, and rivers. Your job is to find out how the input-output systems in these waters respond to these changes. A good place to begin is by investigating the effect of man's output on some of the smallest living things—the microorganisms.

Almost all natural surface waters of the earth contain bacteria and other microorganisms. As you know, decomposers, mostly microorganisms, use the dead bodies and waste output of other creatures as their source of food and energy. As they do this, they take in oxygen from the surroundings and release CO_2.

☐**3-1.** Where do the microorganisms living in surface waters get the oxygen they need to live?

BIOCHEMICAL OXYGEN DEMAND

Most living things must have some oxygen to live. Oxygen is an important reactant in many of the chemical changes that occur in the bodies of living things. Therefore, it is essential that this gas be available in the water environment. The need for oxygen by living things is known as the *biochemical oxygen demand* (B.O.D.).

☐**3-2.** Which organisms that live in the water might be suppliers of oxygen?

The term *biodegradable* will be introduced to the student in the next chapter, so it is not necessary to bring it up here. However, this describes a large percentage of the sewage that is being talked about in this chapter. Microorganisms decompose or degrade these wastes, and essential elements are returned to the environment.

In the series of activities that follow, you will investigate how the B.O.D. of microorganisms is affected by changes in the water surrounding them. Then you may see that the B.O.D., in turn, affects the water.

As mentioned earlier, decay organisms feed on waste material; therefore, sewage is a source of their food supply.

3-3 and 3-4 ask for predictions that the student should be able to make. Normal predictions would be that increasing the food supply of an organism would increase the size of the population, and more organisms would require more oxygen. The student will check his prediction to question 3-4 by an investigation, but the prediction to 3-3 will not be checked.

☐**3-3.** What effect do you predict increasing the food supply of an organism will have on the size of the population of that kind of organism?

☐**3-4.** Suppose the amount of sewage being added to a river were increased. What effect do you predict this would have on the B.O.D. of decay microorganisms?

You could check your answer to question 3-4 by investigating the effects of sewage on decay microorganisms. However, rather than work with such an unpleasant material, you can investigate a similar system that is more sanitary.

If you had Volume 2 of ISCS, you are already acquainted with yeast, a microorganism that uses sugar as a source of food. Yeast will represent the decay organisms in the river water. Powdered milk contains sugar and will represent the sewage that is dumped into the river.

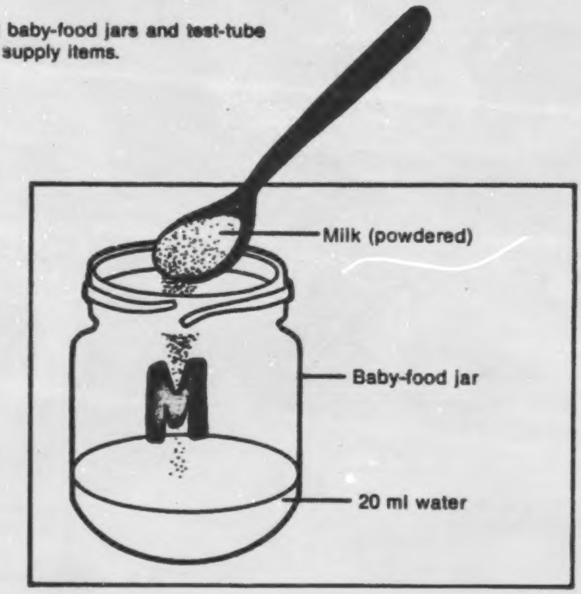
Yeast is a single-celled plant—a special kind of fungi. It breaks down (degrades) the sugar molecules into alcohol and carbon dioxide. Oxygen, if present, is used up in the process.

YEAST
MILK
MILK
MILK
MILK
MILK
MILK
MILK
MILK

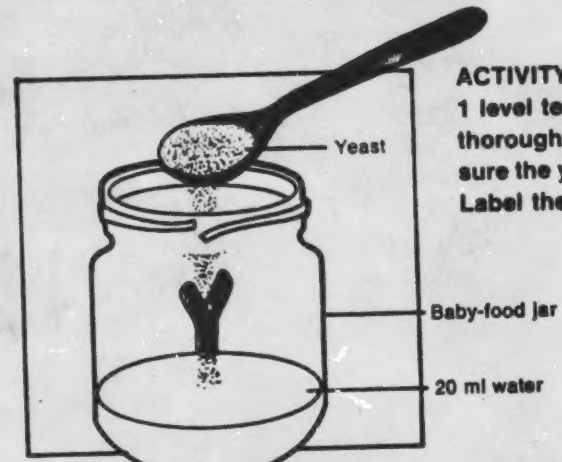
You will investigate how increasing the amount of sewage (milk) affects the oxygen demand of the decay organisms (yeast). To do this, you will need about 25 minutes and the following materials:

Remember that baby-food jars and test-tube racks are local supply items.

- 1 plastic spoon
- 2 baby-food jars
- 1 level teaspoon of powdered milk
- 1 level teaspoon of dry yeast
- 1 dropper bottle of methylene blue solution
- 2 5-ml air pistons
- 1 stirring rod
- 3 test tubes (all the same size with capacity of at least 10 ml)
- 1 test-tube rack
- 1 wax marking pencil
- 1 watch or clock

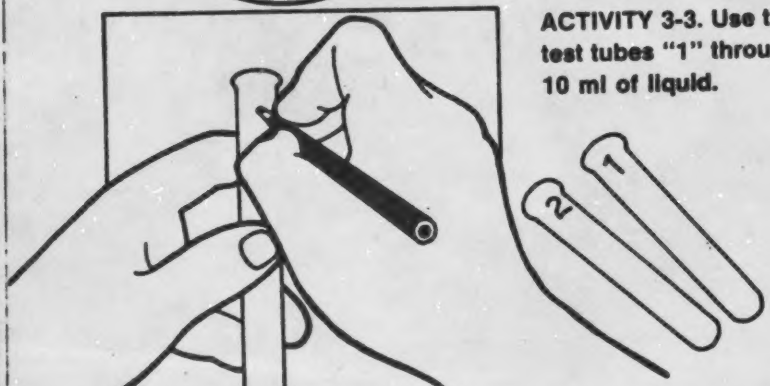


ACTIVITY 3-1. Prepare a sample of milk by slowly stirring 1 level teaspoon of powdered milk into 20 ml of tap water in a baby-food jar. Mark the jar with an "M."

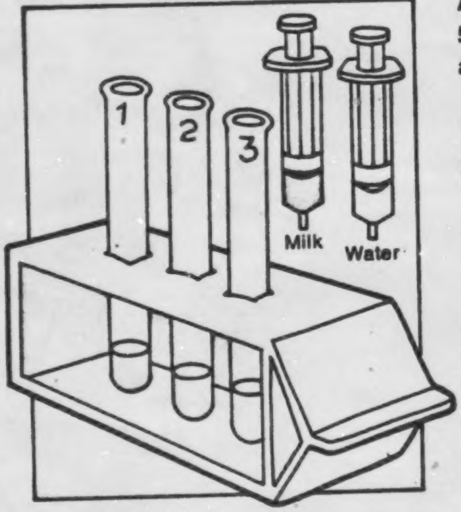


ACTIVITY 3-2. **Prepare a sample of yeast by slowly stirring 1 level teaspoon of dry yeast into 20 ml of water and mixing thoroughly. After a minute or so, stir the mixture again. Be sure the yeast is well mixed and has not settled to the bottom. Label the jar "Y."**

Clean glassware is *vital* in all these activities.



ACTIVITY 3-3. **Use the marking pencil to number three clean test tubes "1" through "3." These tubes should hold at least 10 ml of liquid.**



ACTIVITY 3-4. **Using one 5-ml air piston for water and another 5-ml air piston for milk, add to the three test tubes the exact amounts called for in Table 3-1. Stir each mixture thoroughly.**

☐**3-5.** What is the total volume of liquid in each tube?

☐**3-6.** Which tube has the highest concentration of milk?

☐**3-7.** Which tube has the lowest concentration of milk?

The methylene blue solution you will use next is called an indicator. Its blue color indicates the presence of dissolved oxygen gas. If methylene blue is added to a liquid containing dissolved oxygen, and if the oxygen is then used up, the blue indicator will become colorless. This is illustrated in Figure 3-1. Notice that both tubes show a colored layer at the surface of the liquid.

Test Tube	Milk (ml)	Water (ml)	Concentration of Milk (%)
1	0.5	5.5	8.3%
2	3.0	3.0	50 %
3	6.0	0	100 %

Table 3-1

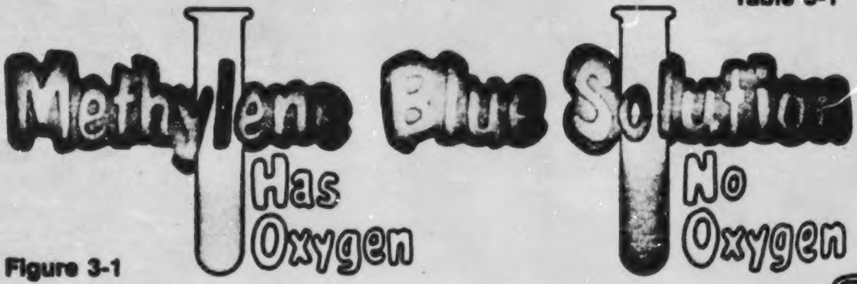
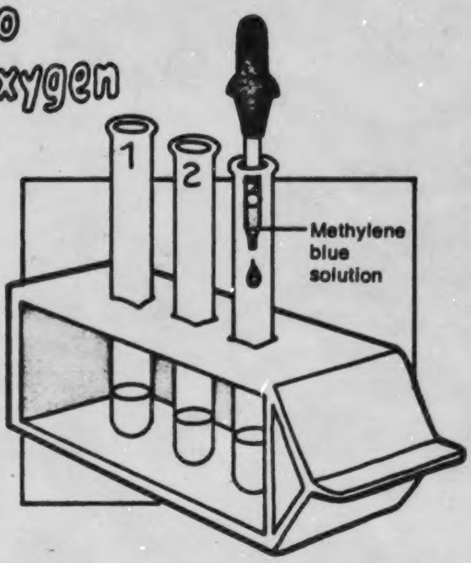


Figure 3-1

☐**3-8.** Why would methylene blue indicate that oxygen is present at the surface of the liquid in Figure 3-1?

ACTIVITY 3-5. Add 20 drops of methylene blue solution to each tube. Mix thoroughly.



☐**3-9.** Does each of the three milk-methylene blue mixtures contain dissolved oxygen?

You are about ready to mix the milk (sewage) and the yeast (decay) microorganisms to see what happens to the B.O.D. The milk mixtures in tubes 1, 2, and 3 represent different concentrations of sewage. Look again at your answer to question 3-4.

☐**3-10.** What do you predict will happen to the blue color in the three tubes if the yeast uses up all the oxygen?

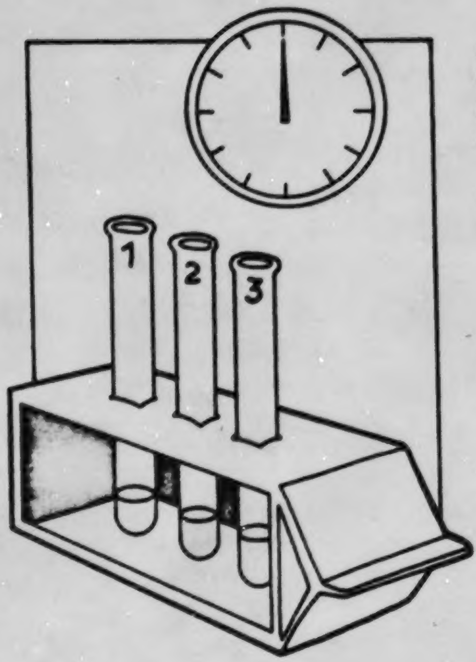
☐**3-11.** In which tube would you expect a change to occur first?

You are now ready to mix these with the microorganisms. Instead of adding the sewage to the yeast, it is easier to add the yeast to the sewage.

You will need about 20 minutes to complete all your observations.

Question 3-8 is an interesting one. The blue layer will remain on the surface after the color has disappeared in the body of the tube. This is because the oxygen from the air dissolves in the upper layer of the mixture. Don't give it away. Let the students ponder and discuss it.

3-11. They should expect the change in the tube with the greatest concentration of milk to occur first if they predicted that an increase in food supply (sewage) for the organisms would increase the B.O.D. in question 3-4.



Note that you are called upon to have a sample tube prepared. This can be one in which a milk solution and methylene blue have been used, with no yeast. Thus it will remain blue in color for comparison purposes. It can be located in an easily observable place and labeled as a sample. A second tube could be prepared with milk, yeast, and methylene blue for the colorless sample.

3-14. Apparently the greater the concentration of milk (food supply), the faster the oxygen is used. Note, however, that students have no way of knowing whether this was caused by an increase in the number of organisms or by increased activity of the organisms present.

ACTIVITY 3-6. Add 2 ml of yeast solution to the first test tube, mixing thoroughly. Record in Table 3-2 the exact time the mixing starts. Once the timing has begun, don't disturb the tube. Jostling it will introduce air into the liquid.

While you are waiting, you should repeat this procedure for the other two tubes. Be sure to record the starting times in Table 3-2.

It may take several minutes for any change to occur. Observe carefully. Record the "Time of change" for each tube when you see that the blue color has disappeared from all but the surface area. Note that because of the addition of the milk-yeast mixture, the solution will not be colorless. Take a look at the sample tube your teacher has prepared. This will help you know when the liquids have lost all their blue color.

Table 3-2

Test Tube	Time for Change to Occur		
	Time of Mixing	Time of Change	Total Time for Change
1			
2			
3			

☐**3-12.** Was your prediction in question 3-10 correct?

☐**3-13.** Did you predict correctly for question 3-11?

☐**3-14.** How do you account for the differences in time required for the color changes to occur?

The more food supplied to the microorganisms, the faster the dissolved oxygen supply is used up. This is what you have observed. How do these observations apply to the decay microorganisms in surface water?

☐**3-15.** What effects would dumping large quantities of sewage into a river, stream, or lake be likely to have on the amount of oxygen dissolved in the water?

When the food supply of a population of organisms is increased, the population usually increases. If the population of an organism increases, the biochemical oxygen demand of that population must also increase. These relationships are illustrated in Figure 3-2.

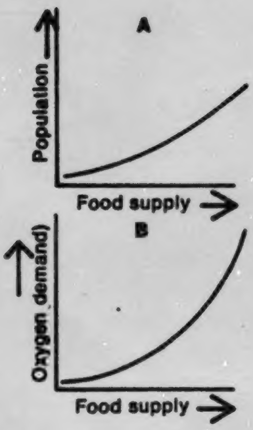


Figure 3-2

☐**3-16.** What do you predict happens to the population of decay microorganisms when sewage is dumped into their environment?

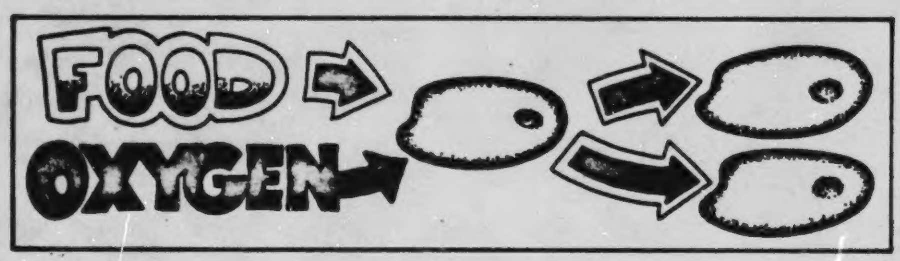
☐**3-17.** Predict the effect an increase in decay microorganisms would have upon their biochemical oxygen demand.

☐**3-18.** What effect would increasing the B.O.D. of one kind of organism population have on the populations of other oxygen-using organisms in the same environment?

3-18. Some may die, or leave the area if they can.

If sewage that is dumped into a lake or river is to be decomposed (reduced to smaller particles), decay organisms must do it. In response to the input of sewage, the organisms increase in number. How fast does the microorganism population increase?

Microorganisms reproduce by dividing. Each one divides into two exactly like the first.



If sufficient food and oxygen are available, some microorganisms can divide as often as every 20 minutes.

This rapid increase in population is an important point in working with living things. The student should have little difficulty with the first few "doublings" (question 3-19, 4 and 8; question 3-20, 64). On the next page, in question 3-21, a 3-hour period will show an increase to 512. But in another 3-hour period, the number will increase to over a quarter million, and will pass the million mark during the 7th hour.

☐**3-19.** Suppose you had one such organism. After 40 minutes, how many would you have? After 20 minutes more, how many would you have?

☐**3-20.** Suppose you started with one microorganism that divides every 20 minutes. Suppose, also, each new organism that is produced lives and is able to continue dividing. How many of the organisms would there be in 2 hours?

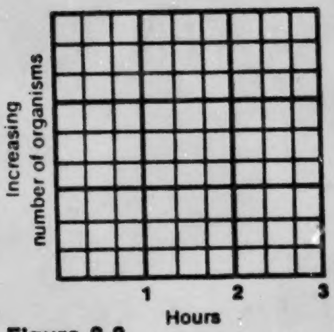


Figure 3-3

3-21. In 3 hours the population will increase to 512, so the scale on the vertical axis must allow for this. On this scale, the first few doublings will be difficult to plot. This may bother some students.

Problem Break 3-1

Without extensive equipment and much time, the student cannot see the increase in yeast population by normal growth. But here he can arbitrarily increase the population and note the effect. Be sure that the amount of milk (food) is held constant.

☐**3-21.** In Figure 3-3 of your Record Book, sketch an approximate graph representing the population increase of the microorganisms during a 3-hour period.

☐**3-22.** How should the increase in an oxygen-using population of microorganisms affect the amount of oxygen present in an environment?

From time to time in this unit, you will be asked to do Problem Breaks. These are problems for you to solve, without much help from your book or your teacher. The problems will usually help you to understand what you are studying in the chapter. But that's not their major purpose. They are designed to give you practice in problem solving, and in setting up your own experiments. You should try every Problem Break—even the tough ones. And in most cases, you should have your teacher approve your plan before trying it. The first Problem Break in this unit is coming up next.

PROBLEM BREAK 3-1

Design an experiment to find out if increasing the amount of yeast increases the amount of oxygen consumed. Let your teacher review your plan before you begin the investigation. Record your plan, results, and conclusions in your Record Book.

Now let's look at what you have found in this chapter. A large input of sewage into surface water upsets the input-output balance. There is a rapid increase in the population of microorganisms (Figure 3-3). As a result of this increase, a great demand is placed on the available oxygen.

This makes it tough on other living things that need oxygen. Even the decay organisms begin to suffer as they use up their oxygen supply. If they can, organisms will move to a more favorable place. Of course, some organisms, such as rooted plants and attached animals, are not able to move.

Decay microorganisms chemically decompose sewage and other wastes. These organisms are very important. They help keep the environment clean. And they are the primary means whereby the chemical elements necessary for life can be released from dead bodies and other wastes to the soil and water. Figure 3-4 illustrates the role of decay organisms.

As long as there isn't an overabundance of waste materials

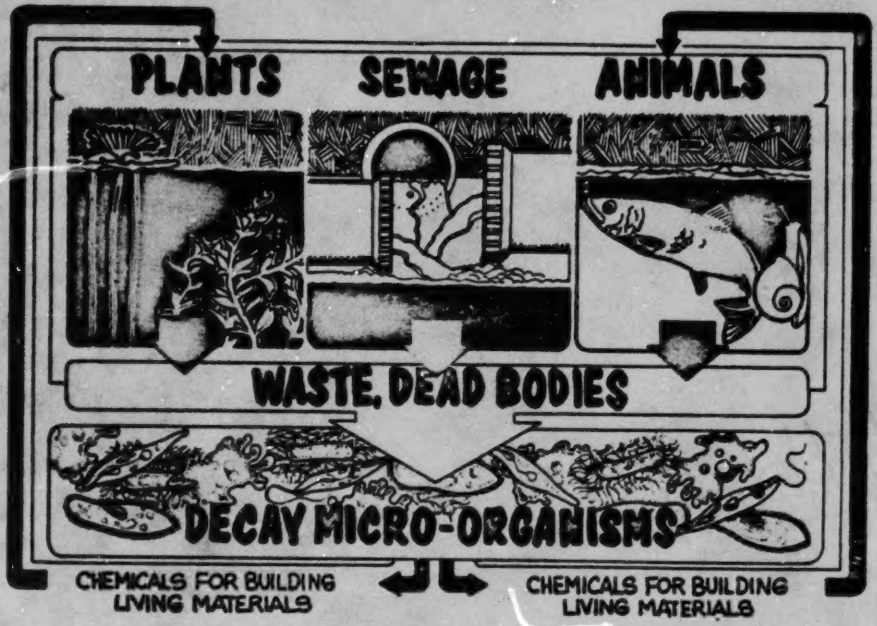

PLANTS
SEWAGE
ANIMALS
WASTE, DEAD BODIES
DECAY MICRO-ORGANISMS
CHEMICALS FOR BUILDING LIVING MATERIALS
CHEMICALS FOR BUILDING LIVING MATERIALS

Figure 3-4

in the water, the microorganisms can decompose most of the chemical compounds that tie up the elements. However, when an abundance of waste material is added to their environment, the microorganisms reproduce rapidly. With the increase in the population, the rate of decomposition increases. This uses up the oxygen in the water more rapidly. This effect of sewage and other wastes on the biochemical oxygen demand is very important. It accounts for the "oxygen death" of many rivers and lakes.

You may want to start a bulletin board display on pollution so that all can read. Save the articles for possible use in later chapters.

PROBLEM BREAK 3-2

The pollution of our environment is receiving worldwide attention. You might want to collect newspaper and magazine articles and pictures related to pollution problems. These could be used in preparing a display for your science room.

In this chapter, you've investigated one kind of water pollution. In the next two chapters, you will investigate additional examples. Before going on, however, you should be sure you are familiar with the "water cycle." To review this important idea, turn to **Excursion 3-1,** "A Drink of the Nile."

Before going on, do Self-Evaluation 3 in your Record Book.

GET IT READY NOW FOR CHAPTER 4

You will need 1% and 5% detergent solutions, and phenol red and methylene blue indicator solutions. Prepare as follows:

1. 1% detergent solution: Mix 1 ml of liquid detergent* with 99 ml of water. Label.

2. 5% detergent solution: Mix 5 ml of liquid detergent* with 95 ml of water. Label.

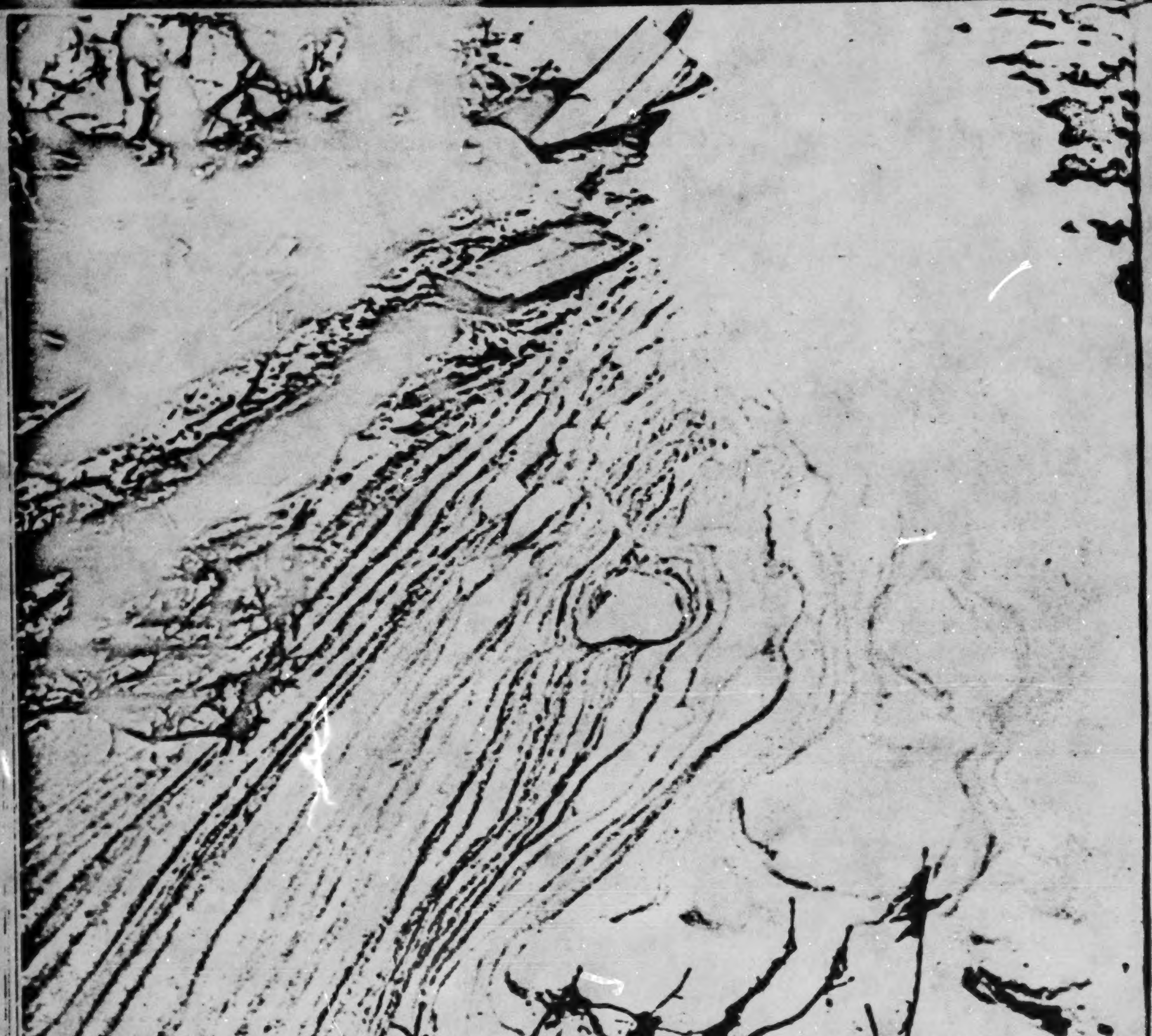
3. Phenol red solution: Use distilled water. Dissolve 1 g of sodium hydroxide pellets ($NaOH$) in 100 ml of water. Label "NaOH Stock." In a separate container, dissolve 1 g of phenol red in 200 ml of water. Label "Phenol Red Stock." To prepare the phenol red indicator as needed, add 4 drops of NaOH stock to 20 ml of phenol red stock. Add water to make 200 ml of the indicator solution. Dispense from labeled dropping bottles.

4. Methylene blue solution: See end of Chapter 2.

***Note: Any brand of detergent will work, but avoid using those with enzymes.**

Excursion 3-1 is for general use.

EXCURSION



51

EQUIPMENT LIST

Per student-team

4 plastic petri dishes with lids
1 paper towel
64 radish seeds
10 ml of 1% detergent solution
10 ml of 5% detergent solution
4 plastic vials with lids
2 ml methylene blue solution
2 ml phenol red solution
Tape

Per Class

Wax marking pencil
1 100-ml plastic graduated cylinder
Scissors
Medicine droppers

CHAPTER EMPHASIS

Contaminants in water may interfere with germination and growth of seedlings; some may tend to accumulate in living creatures in increasing amounts in the food web.

The Undesirables

Chapter 4

Excursion 4-1 is for general use and may be done at home.

MAJOR POINTS

1. Detergents in water interfere with germination of seeds.
2. Greater concentrations of detergents have a greater effect on growth.
3. Chemicals that can be decomposed by microorganisms are said to be biodegradable.
4. Nonbiodegradable chemicals can accumulate in water supplies, and can increase in concentration in succeeding steps of the food web.
5. Nonbiodegradable pesticides can seriously affect species of fish and birds, as well as larger animals.

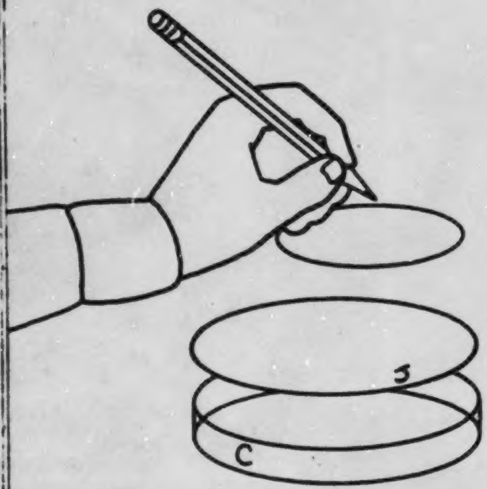
You are very fortunate if you are the first human to use water during its most recent cycle on the earth. Most of us drink water that has already been used by one or more persons upstream. Of course, the used water is usually safe because it has passed through purification plants. However, as the earth's population increases, more and more water is used again and again during its journey to the sea. And it becomes exceedingly difficult to remove undesirable chemicals from water. In this chapter, you will investigate the effects of two substances that can be considered as undesirable—cleaning agents and pesticides. Normally useful to man, these substances are most undesirable in surface water.

Up until the 1930's, soaps were the principal cleaning agents for home and industry. Then detergents were developed. They rapidly became very popular because they had better sudsing properties than soap. Detergents were faster acting and longer lasting. And detergents did not leave the common "bathtub ring" so characteristic of soaps. Unfortunately, the good cleaning features of detergents turned out to be their poorest characteristics as far as surface water was concerned. As detergents from millions of kitchen and bathroom sinks and from thousands of factories and businesses were dumped into surface waters, suds began to collect in rivers, streams, and lakes. Because the detergents are so long-lasting, sudsy water even flowed from taps in some homes! Surely such contaminated water must affect living organisms. Perhaps you would like to see for yourself.

What do you predict will happen to seeds a farmer sows if the water he uses to "get them going" (germinate them) contains detergent wastes? Will the detergent affect the number of seedlings that germinate? Will it affect the seedling's growth?

EQUIPMENT NOTE

The activities in the chapter call for the dispensing of varying amounts of solutions. The detergent solutions in the opening activity can be measured with the graduated cylinder. The methylene blue and phenol red solutions in Problem Break 4-1 can be measured in 1 ml amounts by using medicine droppers. The following method of handling could be used: Place the solutions in stoppered bottles or baby-food jars with caps. Tape a test tube to the side of each bottle or jar. Put a medicine dropper in the test tube. The dropper should stay with the test tube and solution to avoid contamination. In dispensing, 20 drops equals 1 ml. This method could also be used for adding water.

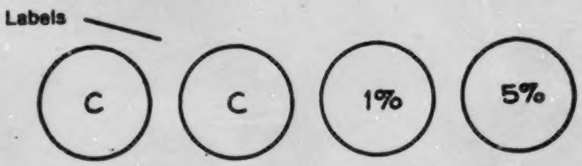


Note that these activities will take several days to complete. The covered petri dishes should not present much of a space problem, since they can be stacked. The seeds do not need light for germination. Be sure that students initial and label their dishes as directed.

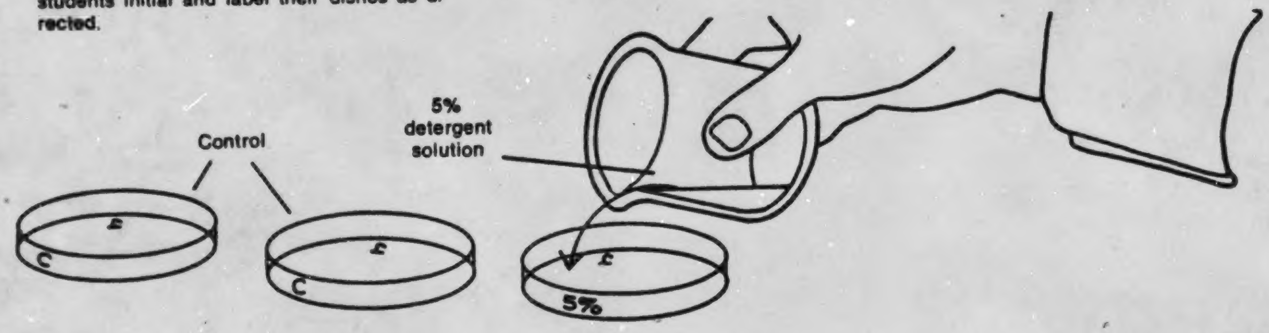
In the following activities, you will try to answer these questions. You will investigate the effect of detergent on the germination and growth of seedlings. You and your partner will need about 15 minutes to set up the investigation. Completion of the experiment will take several days. Rather than wait for things to happen, you will be starting other activities as soon as you get this first one going. Get the following materials:

1 wax marking pencil
4 plastic petri dishes with lids
4 pieces of paper toweling cut to fit the bottom of the petri dishes
40 (approx.) radish seeds
10 ml of 1% detergent solution (already prepared)
10 ml of 5% detergent solution (already prepared)
Tape
Tap water

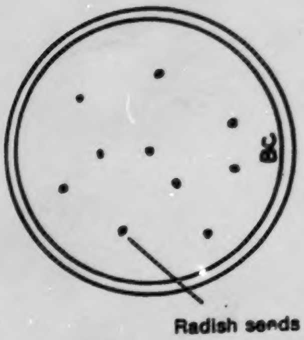
ACTIVITY 4-1. Be sure the petri dishes are clean. Then label them as shown, using a wax marking pencil. Using an ordinary pencil, put your initials on each piece of toweling and place one piece of towel in each dish.



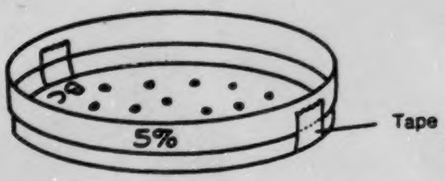
ACTIVITY 4-2. Pour 10 ml of tap water into each of the "control" dishes. Pour 10 ml of the 5% detergent solution into the dish marked "5%." (You are using two control dishes here because you will need them both later.) Put 10 ml of the 1% solution in the dish marked "1%."



ACTIVITY 4-3. Place ten radish seeds in each dish. Spread them out as shown.



ACTIVITY 4-4. Cover each dish with a taped-on lid and put the dishes in a place provided by your teacher. Begin your observations of the seeds during your next class period, as indicated in Activity 4-5.



If you have some time remaining in this class period, you may begin the following problem break.

PROBLEM BREAK 4-1

Do chemical changes occur in a seed as it germinates? For example, does it exchange gases with its environment? Here's how to find out. You will need the following materials:

2 doz. radish seeds	8 ml tap water
4 plastic vials with lids	2 ml phenol red
2 ml methylene blue	

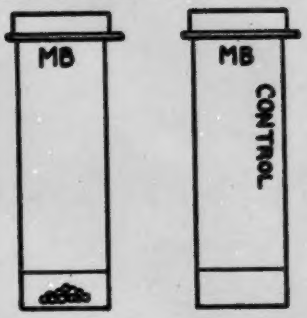
Put about a dozen radish seeds into a plastic vial. Add 2 ml of tap water and 1 ml of methylene blue indicator. Prepare a control by putting 2 ml of water and 1 ml of methylene blue indicator into another vial. Leave the seeds out of the second vial.

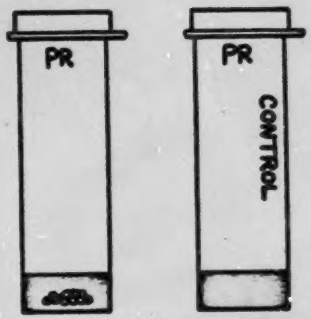
Repeat the same procedure with two more vials, but use phenol red indicator instead of methylene blue. (A change in color of phenol red to yellow can be used to indicate the presence of CO_2 gas.)

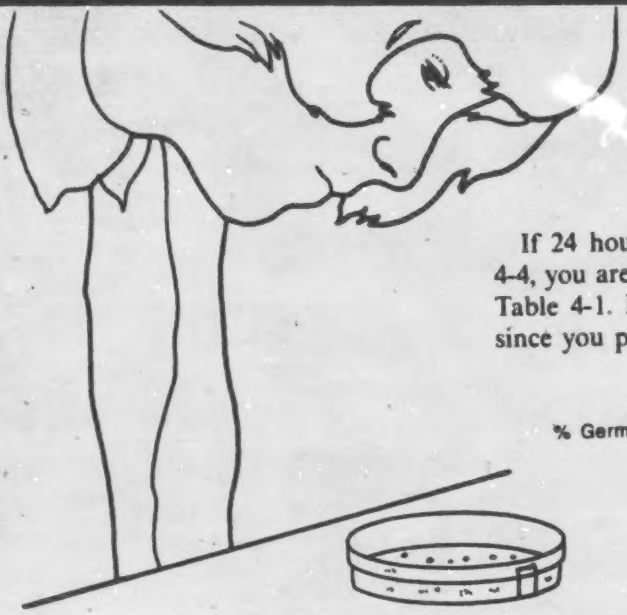
Note and record in your Record Book the initial appearance of each of the four vials. Set them aside in a designated place until tomorrow. Then record your observations again and provide a written explanation of the results. Your discussion should include answers to the following questions:

1. Do chemical changes occur in a seed as it germinates?
2. Do germinating radish seeds, absorb, or release, CO_2?
3. Do germinating radish seeds absorb, or release, oxygen?

Initial appearance: 2 vials, deep blue; 2 vials, red. After 24 hours, vials with seeds have turned light blue and orange respectively. Note that oxygen was taken from the water and carbon dioxide added to the water, so the seeds were respiring. This is not the same as photosynthesis, where oxygen is given off and carbon dioxide is taken in by the plant.







If 24 hours or more have passed since you did Activity 4-4, you are ready to go ahead with Activity 4-5 and to start Table 4-1. Be sure to record how many hours it has been since you put the seeds in the vials.

$$\% \text{ Germinated} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds in dish}}$$

Students may be bothered by the fact that 100% of the seeds in the two control dishes do not germinate. You should point out that even with the best possible conditions, all seeds are not always viable.

ACTIVITY 4-5. Look at the dishes with the radish seeds. Do not remove the covers. Record the percent germinated in the space provided in Table 4-1 of your Record Book. Five out of ten would be 50% germinated. (A seed has germinated if you can see part of a root poking out of it). Don't throw the seedlings away! You'll observe them again and you may want to use them for Excursion 4-1.

Table 4-1

Day Observed	Hours Elapsed	DISH C (Control): % Germinated	1% Detergent Solution: % Germinated	5% Detergent Solution: % Germinated
1				
2				
3				

Note that in Table 4-1 and Table 4-2, more than a day may elapse between setting up the experiment and each of the three observations, because of weekends. This should cause no difficulty, however, if the elapsed hours are filled in.

☐**4-1.** In Table 4-2 of your Record Book, describe the seedlings in each dish. Your description should answer questions such as these:

1. Are the roots, stems, and leaves visible or not?
2. Have the leaves unfolded?
3. Are the leaves yellowish, whitish, or green?
4. Are root hairs (tiny fuzzy growths) visible?

Day Observed	Description of Seedlings in Control Dish	Description of Seedlings in 1% Detergent Solution	Description of Seedlings in 5% Detergent Solution
1			
2			
3			

Table 4-2

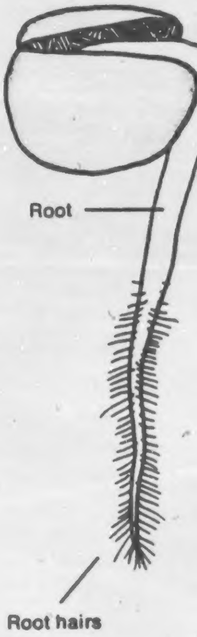
You should keep the covers on the seed dishes so that the water won't evaporate. Observe them again each day for the next two class periods. Record the data that is called for in Tables 4-1 and 4-2.

In the meantime, check the results to Problem Break 4-1. Then go ahead to Problem Breaks 4-2 and 4-3 while you are waiting for the completion of the seed-germination time.

Encourage students to follow through on reading in Problem Break 4-2. If there is a problem about students going to the library, you might consider having reference materials in the classroom for their use. For your information, most of the water is taken in by the root hairs.

PROBLEM BREAK 4-2

You may have noticed the tiny root hairs on the roots of the radish seedlings. Find out what role these root hairs play in the life of a plant. Your school library probably has several books and encyclopedias that can tell you more about plant growth. Record your findings in your Record Book.



PROBLEM BREAK 4-3

Assume you live in a small town and you are the chairman of the city planning commission. A large detergent industry is interested in locating a new plant there. The plant would provide employment for 500 to 600 people. This would add over $1,000,000 per year to the money spent in city stores and for local services. In addition, it would mean tax money for the community. If this company locates in your town, other industries may, in turn, decide to do so. This could be the beginning of major growth for your area.

The company's president admits that the new plant may cause some detergent pollution of a nearby river. He says, however, that at this time his company could not spend more than a few thousand dollars per year in trying to eliminate this pollution.

The amount of discussion called for here will depend on the students in the group. If you see that a group is not getting far, you should suggest an idea to get them going.

This series of questions sums up the results of Tables 4-1 and 4-2. The students should find that the seeds germinate quicker in water than in either detergent solution. For instance, in a typical case, 90% of the seeds germinated in each of the two controls in 24 hours. In the same time interval, in the 1% detergent solution 50% germinated, while none of the seeds showed any activity in the 5% solution. In addition, the roots were much larger in plain water. These differences continue with longer time intervals. By the time of the third observation, the seeds in the control dishes had roots over 3 cm long, heavy root hair growth and well-formed green leaves. The 1% dish was 80% germinated, with short yellow roots and no leaves or root hairs. There was 40% germination in the 5% dish.

As chairman of the city planners, you have to vote for or against allowing the industry to locate in your town. Think about the advantages and the disadvantages to your city. What additional information would help you decide how to vote? What will your vote be and why? Discuss your ideas with some of your classmates.

You should now have completed your investigation of the effects of detergent solution of the germination and growth of seeds. Be sure you have completed Tables 4-1 and 4-2 before going ahead.

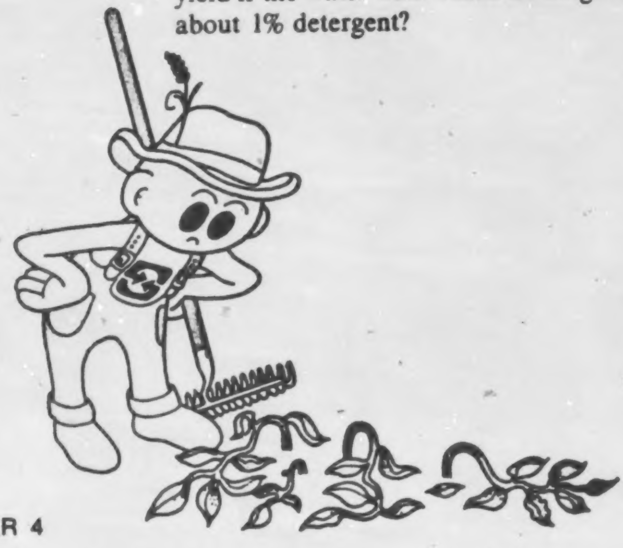
☐**4-2.** Did either the 1% or the 5% detergent solution seem to inhibit (slow down) the germination of the radish seeds?

☐**4-3.** Was the germination of the seeds affected by the detergent? If so, in what way?

☐**4-4.** How many of the seeds in the 5% detergent solution germinated? How many in the 1%? How many in the control?

☐**4-5.** Describe the differences in appearance and size (if there are any) between the control seedlings and those in the 1% and 5% detergent solutions by the time of the third observation.

☐**4-6.** What would you expect to happen to a farmer's crop yield if the water with which he irrigated his crops contained about 1% detergent?



As a result of your investigation, you may have concluded that the farmer could expect a scantier crop of whatever he had planted. You might also have concluded that the plants that lived would be likely to be weak and undersized.

Perhaps you would like to learn more about how detergents could affect crop growth. If so, turn to **Excursion 4-1**. This is an excursion you can do at home if you wish. You will need the control seedlings from Activity 4-5. You may discard the other seeds. To avoid damaging the seedlings, be sure to read the first two activity frames of this excursion now.

Excursion 4-1 uses the seedlings from the two control dishes. Two additional paper towels and a rubber band are needed to prepare the seedlings if the excursion is to be done at home.

◄EXCURSION

The effects on living things of chemical wastes from detergents and from industrial and agricultural processes are very important. These effects may be quite harmful, particularly to organisms living in surface waters. These bad effects result mainly from one of two characteristics of chemicals:

1. Some chemicals can be decomposed and used as a source of food for one or more living organisms.
2. Some chemicals are not easily decomposed and accumulate over a period of time.

In Chapter 3 you found that certain microorganisms decompose chemical wastes. From this decomposition the decay organism gets the food it needs. In addition, essential elements are returned to the environment for reuse by other living organisms.

Chemicals that can be decomposed by organisms are said to be *biodegradable*.

If students have trouble with this word *biodegradable*, you may want to remind them that the powdered milk, which represented sewage, fell into this category. The yeast microorganisms degraded, or broke down, parts of the milk into simpler substances.

BIODEGRADABLE

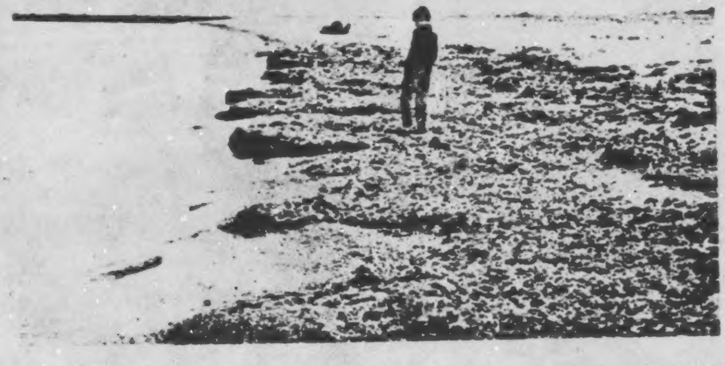
Some of the chemicals from detergent wastes are a source of food for small plant organisms called *algae* (AL jee). Phosphate compounds are good examples. The presence of these detergent wastes in streams or lakes produces rapid growth of these organisms. This increases their biochemical oxygen demand.

☐4-7. What happens to the amount of oxygen available when the B.O.D. of an organism increases rapidly?

☐4-8. How are other oxygen-using organisms affected?

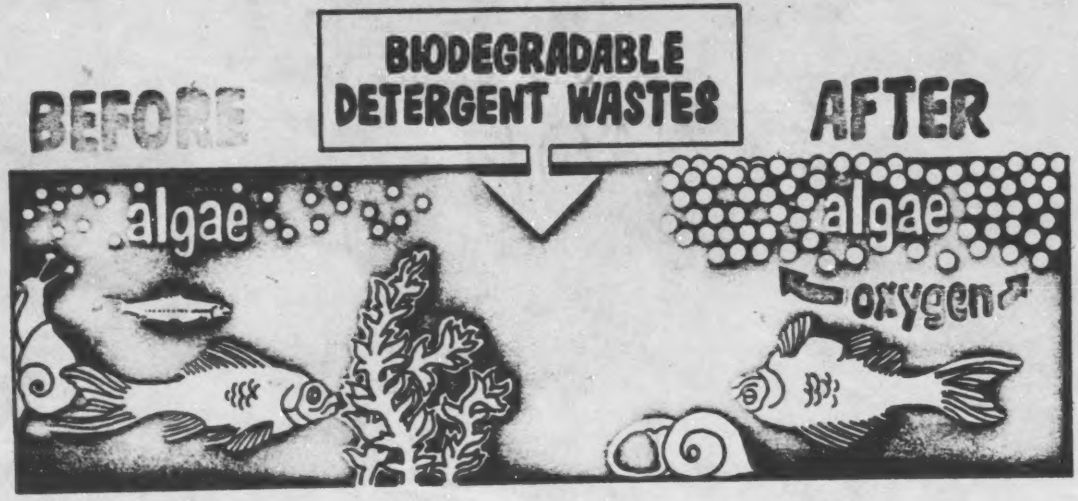
Figure 4-1 shows the result of detergent pollution of Lake Michigan.

Figure 4-1



A rapid growth of algae resulted from an abundance of detergent phosphates. The algae in the lake population increased so rapidly that dissolved oxygen in the water was used up. This loss of oxygen killed the algae as well as other living things. Algae and other dead animal and plant material were then washed up onshore.

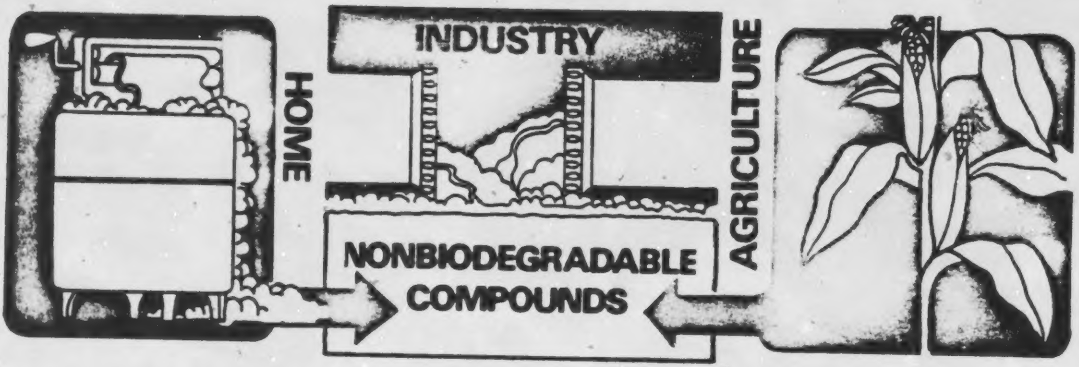
Figure 4-2


BIODEGRADABLE DETERGENT WASTES
BEFORE
AFTER
algae
algae
oxygen

Even though the algae produced oxygen through the process of photosynthesis, they and the microscopic decomposers feeding on algae wastes used up more oxygen than the algae could resupply.

The second effect of chemical wastes in surface waters is also an important one. Some compounds are not decomposed by living organisms. They are said to be *nonbiodegradable*. Detergents can also be sources of some nonbiodegradable chemicals. However, most nonbiodegradable chemicals come from industrial and agricultural wastes. Because nonbiodegradable chemicals are not readily decomposed, these compounds accumulate in surface waters and in the mud of lakes and rivers.

Figure 4-3



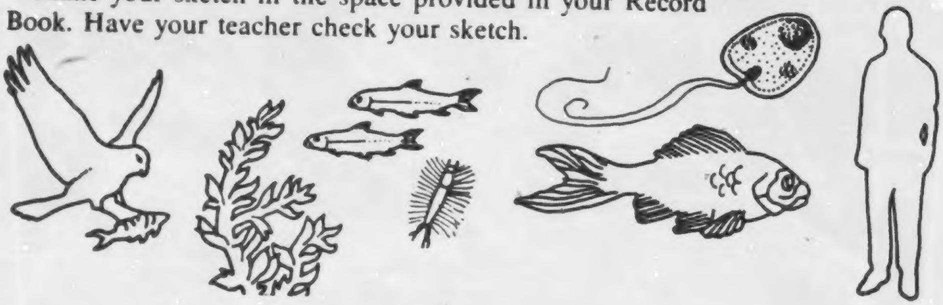
Growing plants and small animals may absorb these compounds along with the nutrients they need. These chemicals may then be passed on to large animals that feed on the plants and smaller animals.

Note that you are called upon to check the students' sketches in question 4-9. The artwork may be crude, but the idea of a "food chain" should show.

☐**4-9.** Use the organisms shown in Figure 4-4 in a sketch that illustrates how nonbiodegradable chemical wastes may be passed from one living thing to another.

Make your sketch in the space provided in your Record Book. Have your teacher check your sketch.

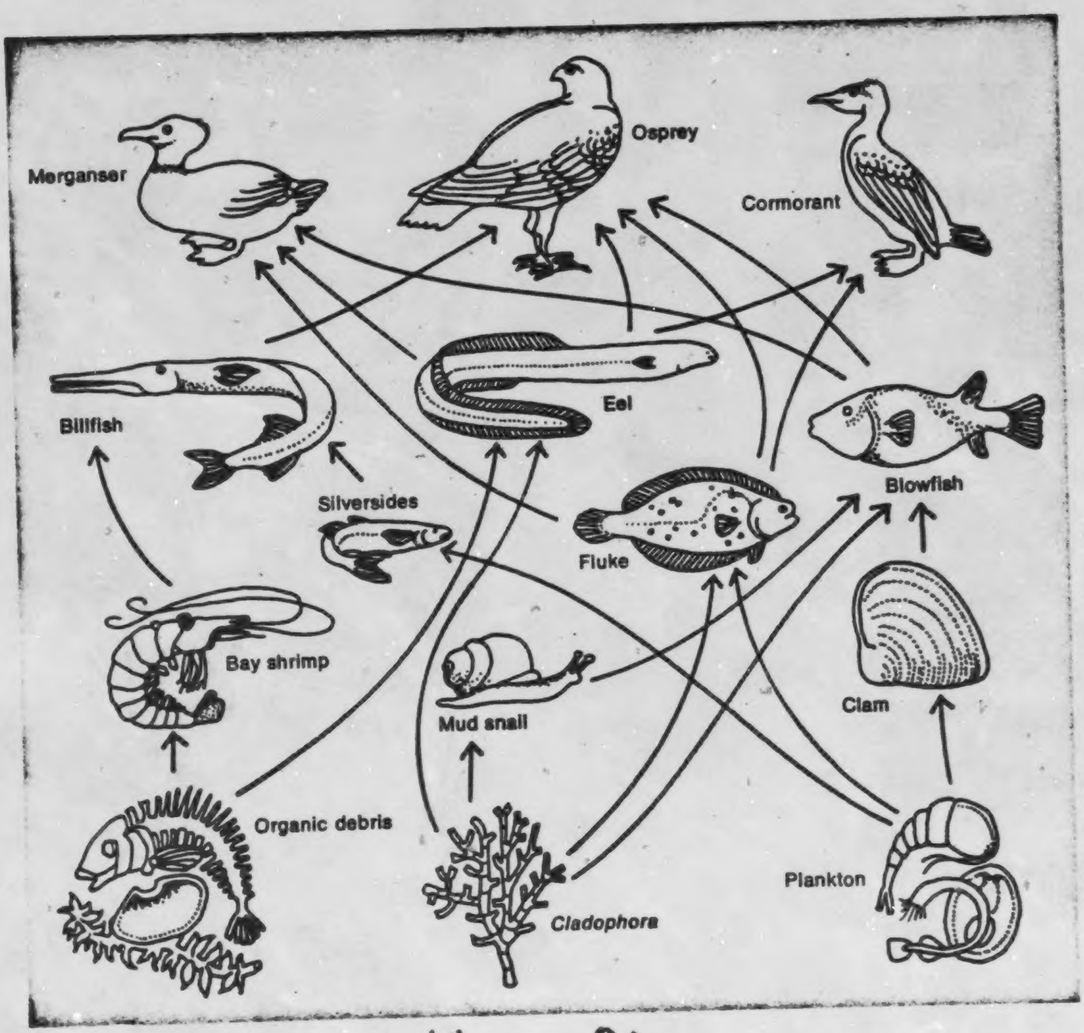
Figure 4-4



☐**4-10.** What harm might result from the accumulation of nonbiodegradable chemical wastes in water supplies?

In the late fall of 1960, large numbers of fish began dying along the southern portion of the Mississippi River. Since that time, millions of fish have died in similar situations. In addition, birds of prey such as the osprey and certain other fish-eating birds have decreased in number. The brown pelican, the state bird of Louisiana, has disappeared from that state's shores. The eggs of fish-eating birds often have thin, soft shells. As a result, the young birds don't hatch.

Figure 4-5


Merganser
Osprey
Cormorant
Billfish
Eel
Blowfish
Silversides
Fluke
Bay shrimp
Mud snail
Clam
Organic debris
Cladophora
Plankton

Careful chemical analysis of the bodies of the dead fish and birds has shown that quantities of chemical insecticides, such as DDT, are present in them. It is now known that these pest poisons (pesticides) have killed or weakened many millions of fish and birds. How does this happen?

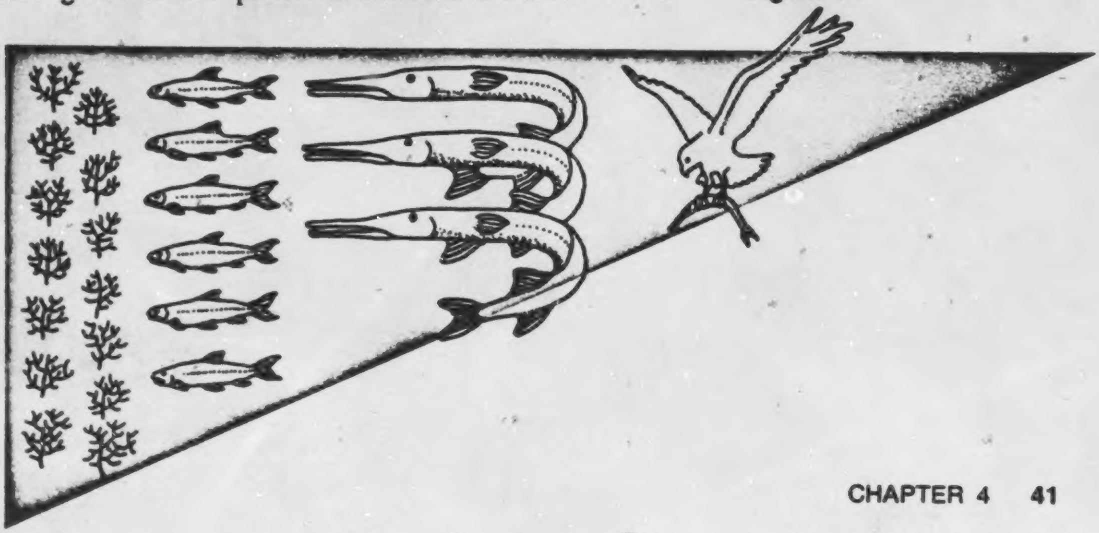
Many pesticides are nonbiodegradable. They are carried by water runoff into streams, lakes, rivers, and oceans, where they may accumulate. These poisons may then be passed along as one organism feeds on another. Figure 4-5 illustrates what is commonly referred to as a *food web*. It shows which organisms serve as food input for other organisms.

☐**4-11.** The osprey and other preying animals suffer more ill effects from nonbiodegradable chemicals than do the plants and animals that they feed upon. How do you account for this? (Figure 4-6 may help you answer this question.)

4-11. The larger the animal, the more it eats and the more chemicals concentrate in its body.

The amount of nonbiodegradable chemical stored in a small plant or plant part is relatively small. But small animals may eat many plants. Thus, more nonbiodegradable chemical gets stored in the small animal than in the plant. Larger animals eat many smaller ones. Because of their larger diet, larger quantities of nonbiodegradable chemicals are taken in and concentrated in their bodies. Figure 4-7 shows the relative buildup of the concentration of one nonbiodegradable chemical by the organisms of the food web shown in Figure 4-5. This particular chemical is DDT.

Figure 4-6



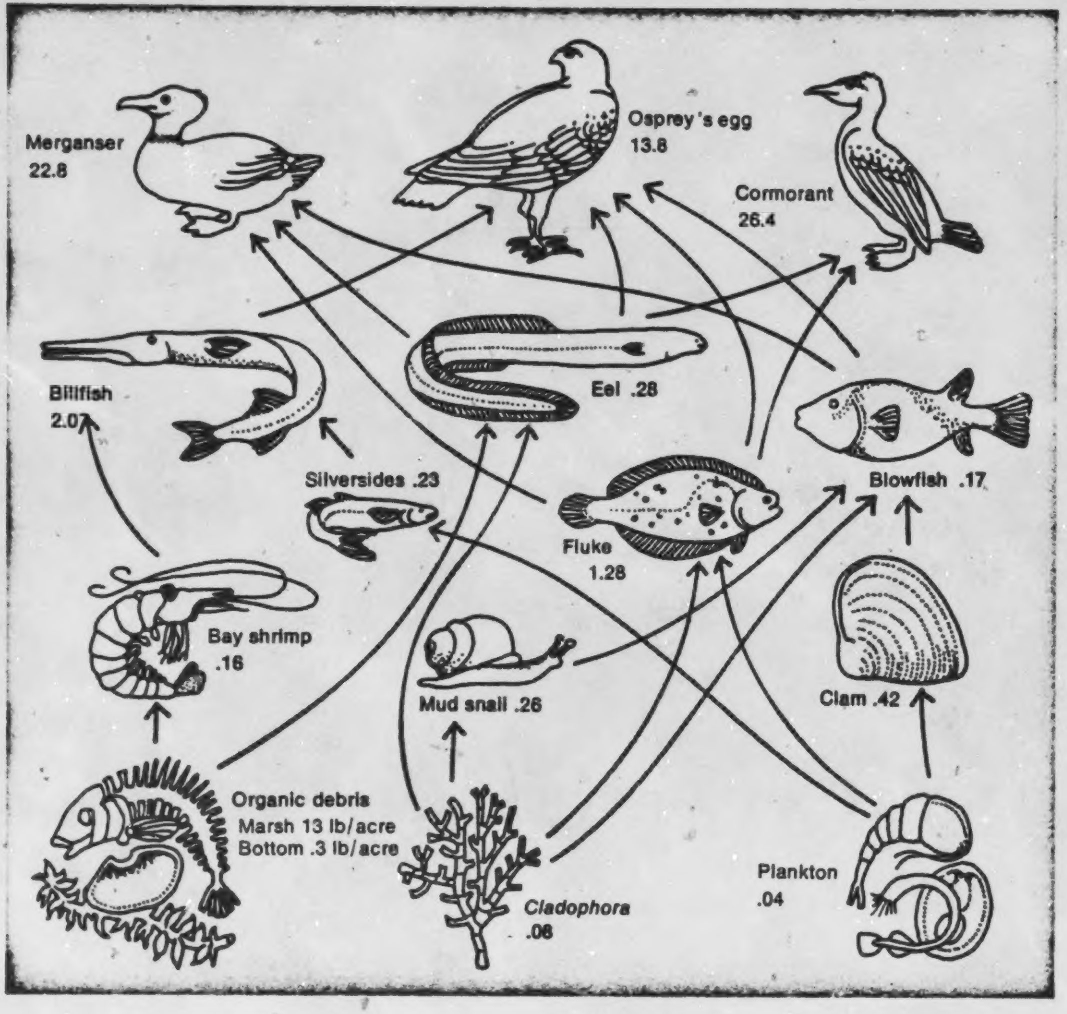

Merganser
22.8
Osprey's egg
13.8
Cormorant
26.4
Billfish
2.07
Eel .28
Silversides .23
Blowfish .17
Fluke
1.28
Bay shrimp
.16
Mud snail .26
Clam .42
Organic debris
Marsh 13 lb/acre
Bottom .3 lb/acre
Cladophora
.08
Plankton
.04

Figure 4-7

☐**4-12.** The federal Food and Drug Administration has banned fish taken from certain rivers and lakes in the United States as unsafe for human consumption (not safe to eat). Explain why this action is necessary.

☐**4-13.** What animals, other than fish, are likely to transfer pesticides to the human body?

☐**4-14.** Do you and your family contribute to pesticide pollution? If so, what can you do to reduce, or eliminate, this contribution?

Problem Break 4-4 on the next page calls for student discussion on pesticides. You may have to suggest some ideas to get the discussion started.

PROBLEM BREAK 4-4

You've just seen some data that show that nonbiodegradable chemicals can be very harmful to organisms that are not pests. Because of this, some people think all pesticides should be totally banned. Others believe this would be disastrous. They point out that without pesticides the production of needed crops to feed an already hungry world would be greatly reduced. Discuss both sides of this argument with your classmates. Then write a summary of the arguments for and against banning pesticides.

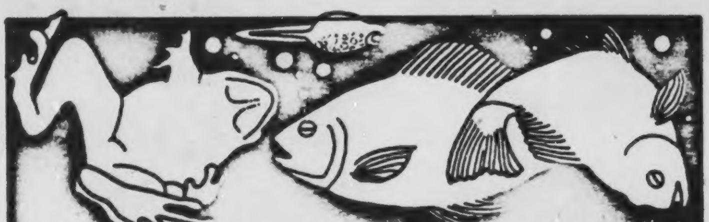
PROBLEM BREAK 4-5

Plant fertilizers are not considered as poisons, yet they may contribute to the death of a lake or stream. Should fertilizers be banned in areas where they contribute to water pollution? List the arguments for and against the use of plant fertilizers such as phosphates and nitrates.

In this chapter you've seen how introducing nonbiodegradable chemicals into surface waters can affect living things. These effects are the result of two basic characteristics of chemicals (see points 1 and 2 on page 37). The effects do not end with just those organisms living in the water. You've also been reminded of the effect some substances have on the biological oxygen demand of plants and animals. In both cases, man has produced environmental changes that affect other living things, as well as himself.

In the next chapter, a different kind of man-made change will be discussed. This environmental change is due to heat.

Before going on, do Self-Evaluation 4 in your Record Book.



GET IT READY NOW FOR CHAPTER 5.

Extensive preparations need to be made for handling the goldfish. You will need at least two tanks to keep them in—an active tank and a rest tank. If you have three or more sections of students, it would be wise to use 3 tanks instead of 2. Of course, if a regular aquarium is available, it will do fine as one of the tanks. The use of rest tanks ensures that the same fish will not be used over and over. Students procure their fish from the active tank and return them to the rest tank. Fish should remain in the rest tank at least an hour before reuse. Capacity of a tank is about 10 fish per gallon of water. If you need to construct tanks, use the bottom halves of gallon-sized plastic jugs. Keep no more than 5 fish in each jug, and use as many jugs as necessary for your fish population. Keep storage tanks out of direct sunlight and be sure that all containers (jugs, baby-food jars, beakers) are clean. Handle fish with the dip net.

When the fish arrive, they will probably be in plastic bags in a special solution. They need to be put into fresh water, but before this is done, the temperatures must be equalized. Simply put the plastic bag, still sealed, into the water in your tank and let it stay for at least one-half hour. Then, using the dip net, transfer the fish from the bag to the tank. Do not add the solution from the bag to the tank. You may use tap water for the tanks, but be sure to let it stand overnight before using. If your tap water is heavily chlorinated, obtain Anti-chlor from a pet shop.

If your tanks do not have aerators, the water should be changed daily, but guard against large temperature changes. Feeding time is once a day, so feeding and water-changing can be done together. Move the fish to a freshwater container at the same temperature. Add plenty of food and let them feed for one-half hour. While they are feeding, empty, clean, and rinse their permanent homes. Replenish the tanks with fresh water (remember earlier instructions) and return the fish to them. *Elodea* can be procured from a pet store to be placed in the tanks. It will help supply oxygen. Other fish can be used if they are readily available in streams in your area.

Figure 4-8

They must be large enough so that respiration can be observed.

Student assistants can take over the task of fish care. However, you should provide initial instruction.

Each student-team will need 2 containers (coffee cans or large beakers), 3 baby-food jars, a test-tube rack and a watch, that must be supplied locally. Be sure to make provisions for the safe filling and handling of the alcohol burners.

EQUIPMENT LIST

Per student-team

2 coffee cans or large beakers
1 alcohol burner
1 burner stand
1 timer with second hand
3 baby-food jars
1 goldfish or minnow
1 thermometer
¼ teaspoon of dry yeast
¼ teaspoon of powdered milk
2 5-ml air pistons
3 test tubes
1 test-tube rack
1 stirring rod
1 plastic spoon
1 250-ml beaker

Per class

Wax marking pencils
Methylene blue solution
Goldfish food
Dip net

Getting All Steamed Up

Chapter 5

In addition to the equipment list above, be sure to provide adequate facilities for the fish. See the teacher notes at the end of Chapter 4 for details.

There are no excursions keyed to this chapter.

CHAPTER EMPHASIS

Increasing the temperature of the environment affects both the activity of living organisms and the amount of available oxygen.

Increasing the concentration of reactants increases the speed of a chemical change. In Chapter 3 you saw how this happens within the earth's surface waters. You found that an increase in the amount of sewage in the water increases the rate of reproduction of microorganisms. As a result, the rate at which oxygen is removed from the water increases. You saw some of the results that this could have on life in the water.

Perhaps you remember another factor that influences the *rate* at which chemical reactions occur. If you've studied Volume 2 of ISCS, you may recall that *temperature* also influences reaction rates.

☐**5-1.** In what way does temperature affect the rate of a chemical change?

As you know, man adds heat to his surroundings from his body and from his fires. Though this added heat may at first not seem important, it really is. For example, huge quantities of water must be heated to steam each day to produce electricity. This water is taken from great rivers and lakes. After the water has been heated to steam and then used to drive turbine generators, it cools a bit and changes back to liquid water. This hot liquid is then pumped through an outlet pipe back into the river or lake from which it came.

This large quantity of heated water dumped into lake, river, or ocean may be free of chemical pollutants. However, because it is still hot, the temperature of the water near the power plant outlet can be raised several degrees Celsius above the normal temperature. What effect would this heating of the surface water have on animals and plants?

MAJOR POINTS

1. Temperature influences the rate of a chemical reaction.
2. Living organisms use oxygen faster at higher temperatures.
3. Breathing movements of a fish can be used as an indicator of oxygen consumption.
4. A fish is classified as cold-blooded, in comparison with a mammal, which is warm-blooded.
5. There are temperatures above which fish and other living things will die.
6. This critical temperature varies for different living things.
7. Less oxygen will dissolve in water at higher temperatures.
8. Heat buildup in water is called thermal pollution.

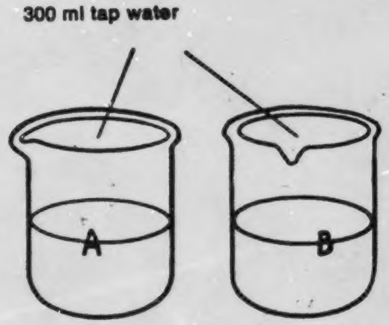
In the following activity you will be given a chance to collect the data necessary to answer that question. Goldfish, or minnows, will be the experimental animals you will use. You will test the effect that mild heat has on them.

Working with a partner, you will need about 30 minutes and the following materials:

2 containers (coffee cans or large beakers)
1 alcohol burner
1 burner stand
1 timer, or watch with second hand
1 baby-food jar and lid
1 goldfish or minnow
1 dip net
1 thermometer

Some teachers have found that *Gambusia* (mosquito fish) can be substituted for the goldfish with marked success. These seem to survive much better under almost any conditions, and require very little care.

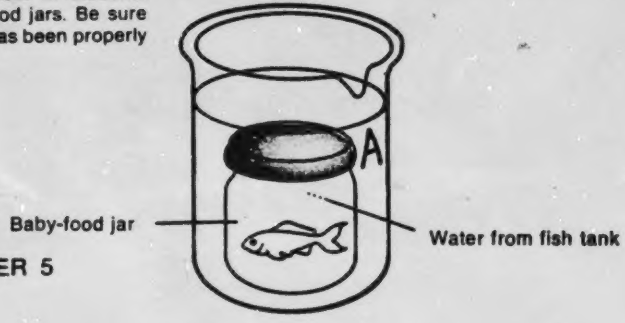
Caution *It is extremely important that you use only clean glassware when working with living things. Contaminated equipment can mean certain death for your fish. To be sure your glassware is clean, wash it thoroughly with water before you begin the activities. Do not use soap or detergents. Also, pay very close attention to the instructions in each activity. This will be a matter of Life and Death—for the fish.*



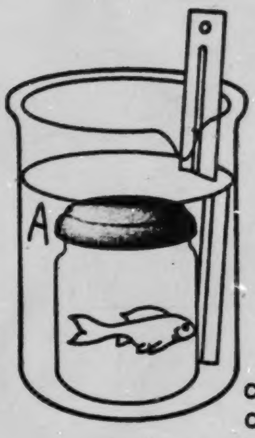
ACTIVITY 5-1. Place about 300 ml of tap water in each of two containers. Label the containers "A" and "B."

ACTIVITY 5-2. Fill a baby-food jar almost to the very top with water from the fish tank. Using a dip net, add one fish from the "ready" tank to the jar. Cap the jar and place it in container A.

You may have to monitor the water level in your "ready" tank if a number of students remove water in the baby-food jars. Be sure to replace it with water that has been properly prepared.



ACTIVITY 5-3. **After a few minutes, record in Table 5-1 the temperature of the water in container A. Then determine the relative activity of the fish by counting the number of breathing movements (opening and closing of the mouth or gills) that occur in 20 seconds. Have your partner time you as you count. Take at least three complete 20-second counts and find the average. Record all measurements in Table 5-1. Be patient—your fish may move about and interrupt your counting. If so, start your count over again.**



There could be a danger of heating the water too much in Activity 5-4. You might want to suggest that, as an alternative method, the water in container B first be heated to 35°C without the fish jar in it. Then the baby-food jar with the fish in it can be placed in the warm water after its removal from the stand. This could save some fish.

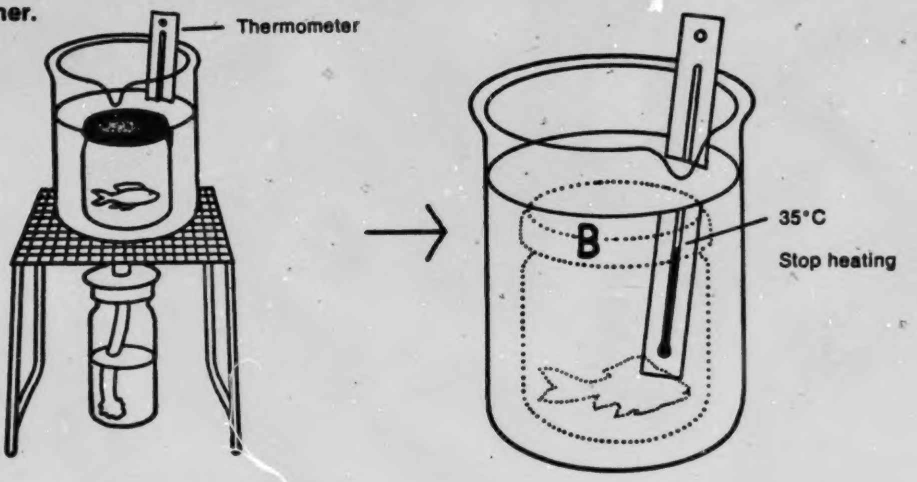
Count X
Count Y
Count Z

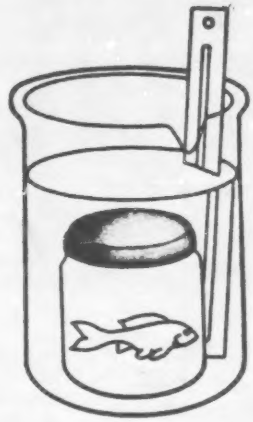
$\text{Average} = 3\overline{)X + Y + Z}$

Table 5-1

Container	Temperature	Activity (respiration for 20 sec.)	Average Count	Other Observations
A		1. 2. 3.		
B		1. 2. 3.		

ACTIVITY 5-4. **Place the jar with the fish into container B. Heat the container and its contents. When the water is 35°C (no hotter), remove the burner.**



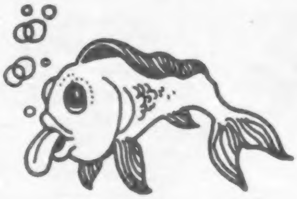


ACTIVITY 5-5. Now, determine the activity of the fish as you did in Activity 5-3. Record in Table 5-1 these data and any other observations you make of the behavior of the fish. Again, be patient in observing your fish. It may take a while to get three 20-second counts.

Being cold-blooded animals, fish are well-suited to an aquatic environment. Water temperatures generally change very gradually and the fish are not required to make sudden adaptations. If rapid changes do occur, however, the fish must move or die. This is a good reason for avoiding sharp changes in temperature with your goldfish. They cannot move to another location.

Be careful of the sudden change in temperature in returning fish to the rest tank. A good procedure would be to remove the cap from the jar and then place the jar into the rest tank, where the temperatures could equalize.

When you have completed the activity, put the fish into the "rest" tank so that another student won't use it right away.

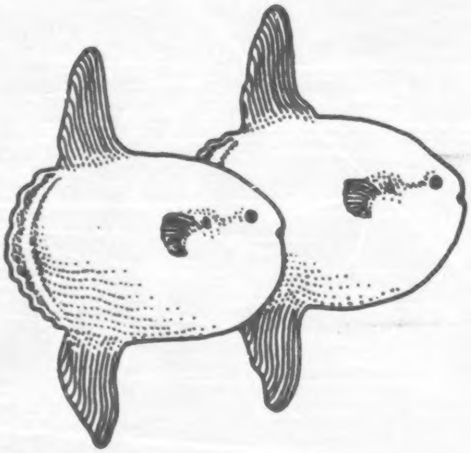


☐**5-2.** How did the breathing rate of the fish in warm water compare to that of the fish in the cooler water?

☐**5-3.** Did the fish seem more active in the warmer, or in the cooler, water?

A fish is *cold-blooded,* which means that its body temperature adjusts to the same temperature as that of the surroundings. A *warm-blooded* animal is one whose body temperature stays about the same even when the temperature of the surroundings changes.

☐**5-4.** Would you be classified as warm-blooded, or cold-blooded?



☐**5-5.** Suppose an ocean sunfish had been swimming north from Florida, staying in the warm Gulf Stream. And suppose it entered the much colder water near the Maine coast. What do you predict would be the effect of the colder water on the fish's temperature? How would the fish's activity probably change?

5-5. Student should predict that the fish's temperature would decrease. Of course, its activity should decrease also. Surprisingly, some students will say that the activity will increase. They have a feeling that cooler temperatures make all living organisms more energetic.

Your observations probably showed that a fish is affected by changes in temperature. Increased breathing rate and greater activity result from increased temperature.

☐**5-6.** What do you predict would happen to the breathing rate if your fish were gradually cooled to a low temperature?

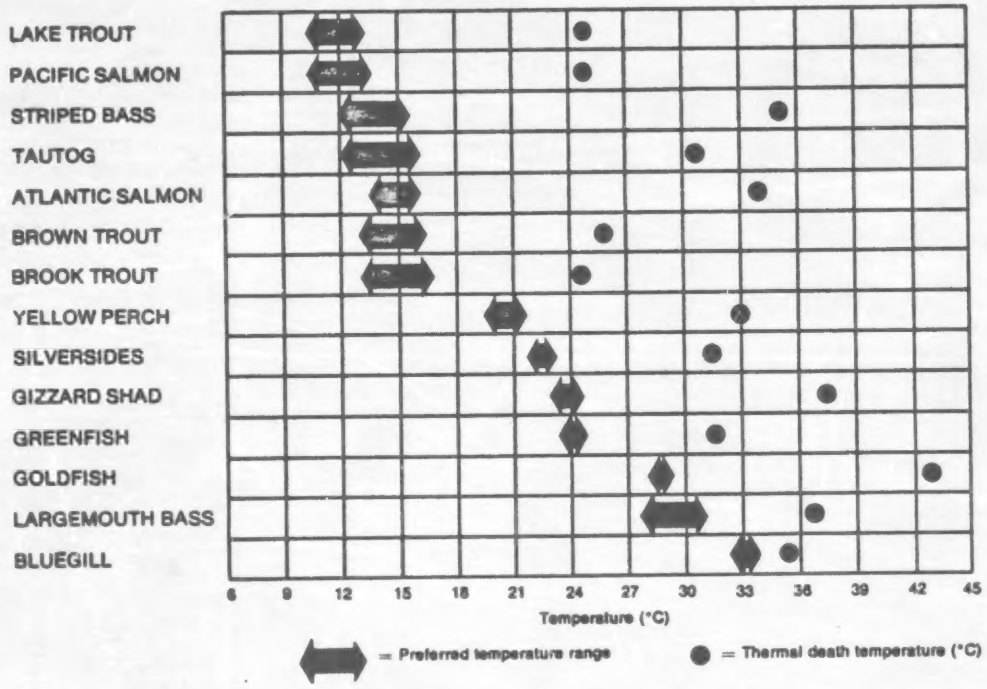
OPTIONAL ACTIVITY. You may want to find out whether your answer to question 5-6 is correct. If so, you should get your teacher's approval of your plan.

If the student elects to do the optional activity, be sure that the plan you approve includes clean glassware and a gradual temperature decrease.

What do you predict would be the effect on fish other than goldfish or minnows of being placed in warm water? Would they react as your fish did? The answer is generally Yes. However, some fish are much more sensitive than others to increases in temperature. Examine Figure 5-1.

Figure 5-1 shows the range of temperatures preferred by various fish. It also shows the thermal death point (temperature at which they will die) for these fish. You examined the breathing rate of goldfish at 35°C. Eight degrees warmer, and your fish could have died.

Figure 5-1



☐**5-7.** Judging from Figure 5-1, what do you predict would have happened to a greenfish if you had heated its surroundings to 35°C?

☐**5-8.** In terms of temperature effects, why do you think goldfish make better pets than do brook trout?

5-8. Goldfish can live in water at room temperature; brook trout would have to be kept in colder water.

You should be getting an idea of why adding heat energy to rivers, lakes, bays, and streams can present real problems for fish. But what about other aquatic (water) animals? The next problem break will give you a clue.

PROBLEM BREAK 5-1

A junior high student in California studied the effect of increased temperature on saltwater animals. The survival time of the animals was determined for different water temperatures. Table 5-2 contains the data.

Coastal waters near power plants may be up to 12°C warmer than the normal 9°–12°C range given in Table 5-2. Under such conditions, some of the animals would surely die. What would these animals have to do to survive? How would this upset the local balance of nature? Discuss your ideas with your classmates; then enter your conclusions in your Record Book.

All the animals in Table 5-2 are cold-blooded. In order to survive, they would have to move. The fish might have little difficulty doing so; with the hermit crabs, it might be harder. The anemone population could be wiped out. In any case the local balance of nature would be affected. All the varieties of life in water serve as support in one way or another for other living things.

Table 5-2

Group	H_2O Water Temperature (°C)	Cottids	Blennies	Hermit Crabs	Anemones
I (control)	9–12	All lived throughout the experiment.			
II	15	All lived two or three days.			
III	18	3 hr.	3+ hr.	5 hr.	5+ hr.
IV	21	1-2 hr.	1-2 hr.	1 hr.	5+ hr.
V	24	0.5 hr.	0.5 hr.	0.5 hr.	5+ hr.
VI	27	0.25 hr.	0.5 hr.	0.5 hr.	3 hr.

You have seen data showing that fish cannot survive in water above a certain temperature. The data in Table 5-2 also showed that other aquatic animals are sensitive to temperature changes. Actually, all animals are "temperature sensitive." Man is certainly no exception. He prefers a constant temperature of about 20-25°C. This is why he uses heaters in the winter and air conditioners in the summer.

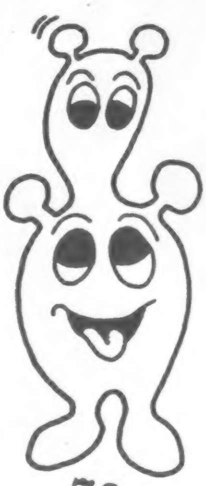
You probably recall that increased temperature increases the rate of chemical reactions. If you studied Volume 2 of ISCS, you also know that chemical reactions occur within living organisms.

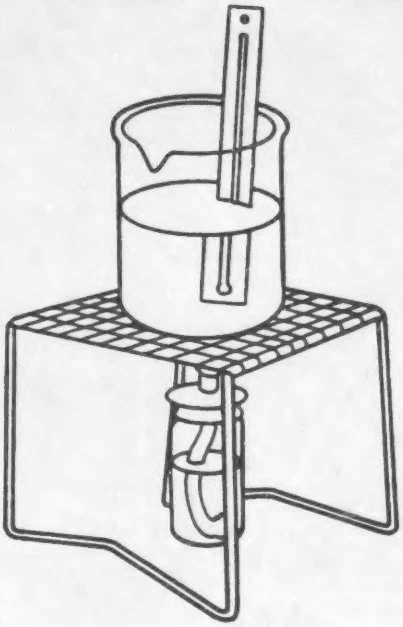
☐**5-9.** How would the chemical reactions inside the fish be affected by increased water temperature?

To check your answer to question 5-9, you will need to do another investigation. You should try to find out if increased temperature affects the rate at which a living organism uses oxygen. Instead of using a fish, you will again use the microorganism yeast. You can follow a procedure similar to one you used in Chapter 3.

You and a partner will need about 20 minutes and the following materials:

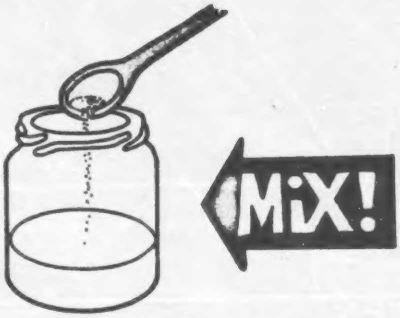
Dry yeast
Powdered milk
1 dropper bottle of methylene blue solution
2 5-ml air pistons
3 test tubes (all the same size with capacity of at least 10 ml)
1 test-tube rack
1 stirring rod
1 plastic spoon
1 250-ml beaker
1 burner stand
1 alcohol burner
2 baby-food jars
1 timer or watch
1 thermometer
1 wax marking pencil



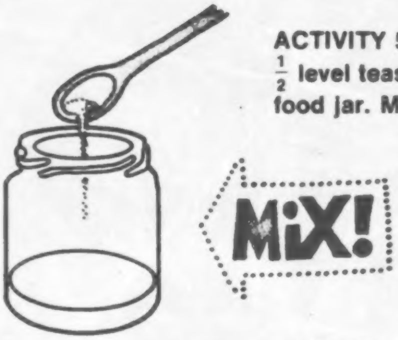


ACTIVITY 5-6. Begin heating a 250-ml beaker half filled with water. You may then go on to the next activity, but keep an eye on the beaker. When the water temperature is at 40°C, remove the burner.

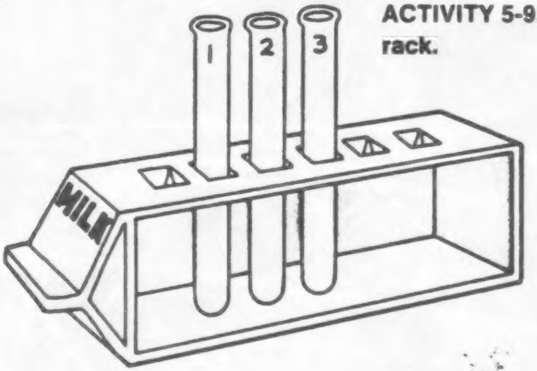
ACTIVITY 5-7. Prepare a sample of milk by adding $\frac{1}{2}$ level teaspoon of powdered milk to 20 ml of water in a baby-food jar. Mix thoroughly.



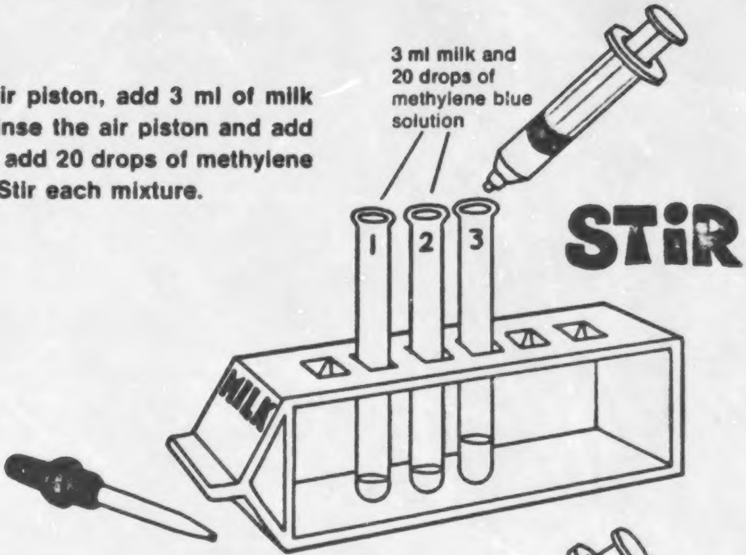
ACTIVITY 5-8. Prepare a sample of yeast solution by adding $\frac{1}{2}$ level teaspoon of yeast to 10 ml of water in the other baby-food jar. Mix thoroughly.



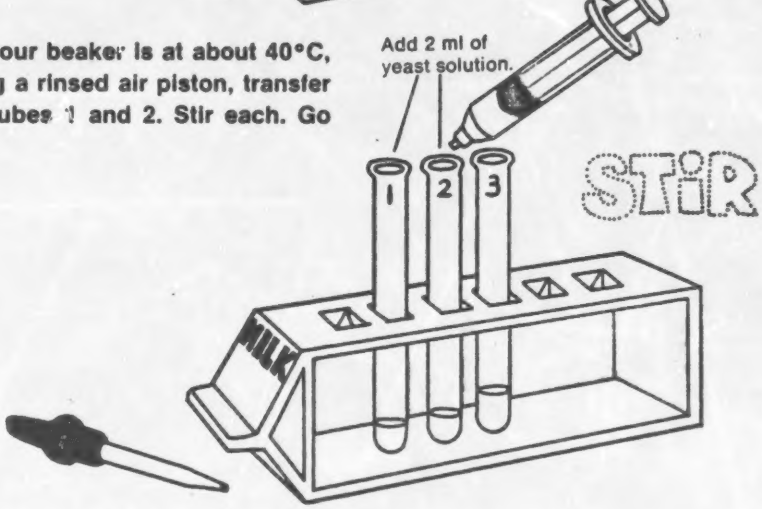
ACTIVITY 5-9. Place three labeled test tubes in your test-tube rack.



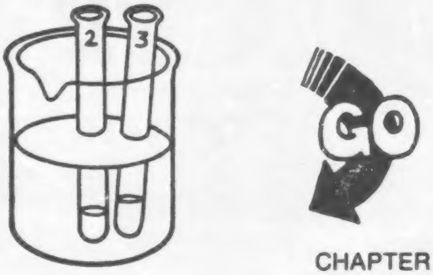
ACTIVITY 5-10. Using the 5-ml air piston, add 3 ml of milk solution to test tubes 1 and 2. Rinse the air piston and add 5 ml of water to test tube 3. Then add 20 drops of methylene blue indicator to each test tube. Stir each mixture.


3 ml milk and
20 drops of
methylene blue
solution

ACTIVITY 5-11. If the water in your beaker is at about 40°C, you are ready to proceed. Using a rinsed air piston, transfer 2 ml of yeast solution to test tubes 1 and 2. Stir each. Go quickly to the next activity.


Add 2 ml of
yeast solution.

ACTIVITY 5-12. Quickly put test tubes 2 and 3 into the beaker of warm water. Record the time in both rows of Table 5-3.


Warm (35°-40°)

As in Chapter 3, you can expect a blue ring to remain at the top of tubes 1 and 2 because of contact with the air. And, of course, there will be no loss of color in control tube 3, so students may have to be warned not to continue watching it.

Observe each tube carefully. Watch for a complete color change (decolorization) in all three tubes. If it occurs, record the time in Table 5-3.

Table 5-3

Test Tube No.	Temperature (C°)	Starting Time from Activity 5-12	Time When Color Disappears	Total Time for Decolorization (minutes)
1	Room temperature (24-26°)			
2	Warm (35-40°)			
3	Warm (35-40°)			

Table 5-3. Test tube #1 should change to colorless in 12-15 minutes. Test tube #2 should require about half as long (6-8 minutes). Test tube #3 does not change.

5-10. An increase in temperature increases the rate of reaction—that is, the yeast use up the oxygen faster at a higher temperature. In addition, the factor discussed on the next page enters into the situation.

☐**5-10.** Did the time for decolorization in test tubes 1 and 2 vary with the temperature? Why?

☐**5-11.** Did increasing the temperature increase the rate at which oxygen was used up by the yeast?

☐**5-12.** Test tube 3 was used for what purpose?

☐**5-13.** Did heating alone change the color of methylene blue?

☐**5-14.** Were the rates of the chemical changes in the yeast bodies affected by an increase in the temperature of the water?

☐**5-15.** Is it reasonable to assume that the rates of chemical changes in a fish's body would increase with increased temperature?

Living organisms use more dissolved oxygen when the temperature increases. This could account for the more rapid decolorization that occurred with the yeast in warmer water. However, there is another reason that decolorization occurred more rapidly in the heated water. Table 5-4 should give you a clue.

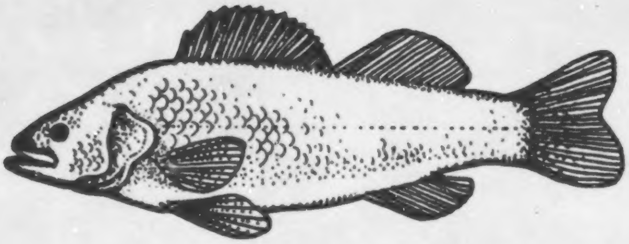


Table 5-4

Temperature °C	Amount of Oxygen Gas That Will Dissolve in Water (gm/100 ml)
0	0.0069
10	0.0054
20	0.0043
30	0.0036
40	0.0031
50	0.0027
60	0.0023
70	0.0019
80	0.0014
90	0.0008
100	0.0000

☐**5-16.** Living organisms use more oxygen in warm water than in cold. According to the data in Table 5-4, what other factor causes the oxygen supply to be used up more rapidly in warm water than in cold?

Increasing the temperature of surface water increases the biochemical oxygen demand of living things. It also decreases the amount of dissolved oxygen.

☐**5-17.** If an aquatic animal required a lot of oxygen, would you expect to find him living in cold, or warm, water? Why?

☐**5-18.** Where would you expect to find more life, in warm or in cold water? Explain your answer.

☐**5-19.** What effects do you predict heat pollution would have on living organisms in surface waters?

The decrease in dissolved carbon dioxide in water as the temperature increases is even more dramatic than that for oxygen. Consequently, aquatic plants are greatly affected by thermal pollution. You probably have noticed this effect as a carbonated soft drink sits on the table and gradually warms up. Bubbles of carbon dioxide are released in increasing numbers.

5-17. In cold water, because more oxygen can dissolve in cold water than in warm water.

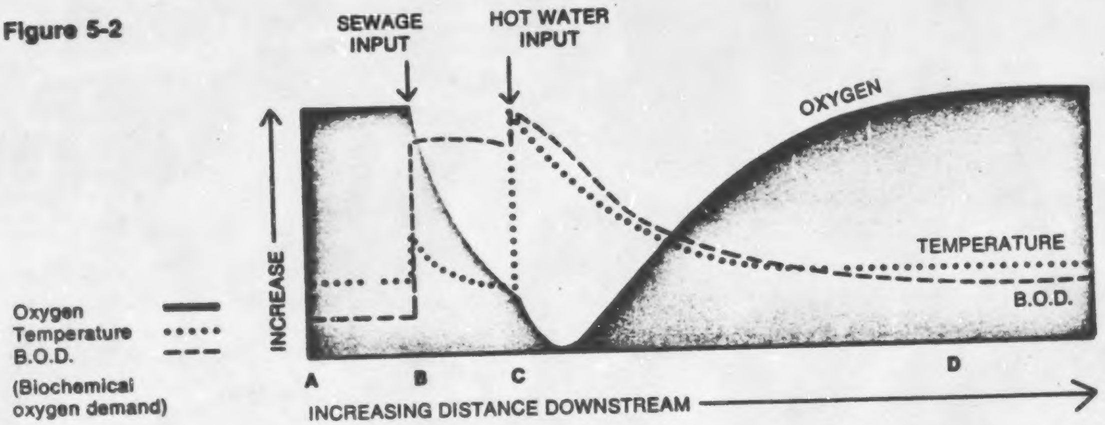
5-18. In cold water, for the same reason. In all fairness, it probably should be pointed out that, although this chapter is focusing on heat pollution, many fish have been killed by decreases in temperature as well. Strong winter gales may flood the bottom of a bay with abnormally cold water, resulting in huge fish kills. Similarly, shallow lagoons may be chilled by low surface temperatures, which kill many living things.

PROBLEM BREAK 5-2

Examine Figure 5-2 below. It summarizes data obtained from studying a polluted river. The vertical scale carries the single label "increase" and no units because the three graph lines are for different things. A line sloping upward means an increase in whatever the line represents. A down-sloping line shows a decrease in whatever it represents. (The key in the margin identifies each graph line.)

Figure 5-2 may confuse students because they are probably not familiar with three graphs on a single figure. You might want to suggest that they sketch each graph line separately on scrap paper.

Figure 5-2



Between points **A** and **B**, you see the natural oxygen level, temperature, and biochemical oxygen demand (B.O.D.) in the river before it is polluted with sewage. At point **B**, sewage is dumped into the river; and at **C**, hot water is added.

Using the graph, answer the next six questions, recording your complete answers in your Record Book.

1. What happened to the oxygen content when the sewage was dumped into the river? Explain why this happened.
2. What happened to the oxygen content of the water when heated water entered the river? Explain your answer.
3. At what two points was there an increase in the river water temperature?
4. What happened to the B.O.D. when the sewage was added to the river? Explain why this happened.
5. What happened to the B.O.D. in the warmer water? Explain why this happened.
6. Explain the change in the oxygen content, the B.O.D., and the temperature by the time water has moved downstream to point **D**.

1. When sewage was dumped into the river, the oxygen content dropped sharply. This was because of an increase in the B.O.D. by the decay microorganisms.
2. When heated water entered, the oxygen content dropped still further. An increase in temperature had two effects. It increased the activity of the decay organisms, using more oxygen, and it allowed less oxygen to be dissolved in the water.
3. The river water temperature increased slightly at point B because of the increased reaction between sewage and decay organisms. It increased more at point C because of the hot water input.
4. The B.O.D. increased because the decay organisms needed more oxygen to degrade the sewage (see 1 above).
5. The B.O.D. increased again. See 2 above.
6. By the time the water had reached point D, heat had been lost to the surroundings, the water had absorbed additional oxygen, and a large amount of the sewage had been degraded by the decay microorganisms. This resulted in increased oxygen content, decreased B.O.D., and decreased temperature of the water.

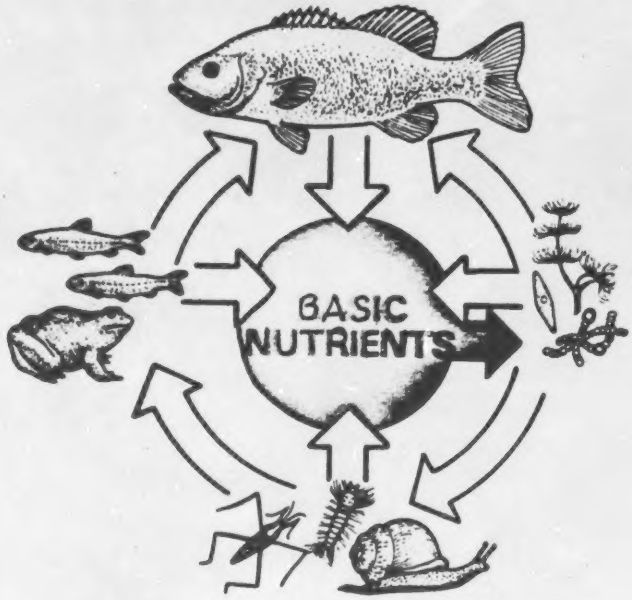
As you've seen in this chapter, accumulation of heat in surface waters can produce important changes in the aquatic environment. This heat buildup is called *thermal pollution.* Combined with his output of sewage and other chemical pollutants, man's thermal pollution is seriously upsetting balanced systems of plants and animals. Because man is part of the system, he too is affected by the environmental changes he causes. The food he eats and the water he drinks carry the results of his own pollution back to him.

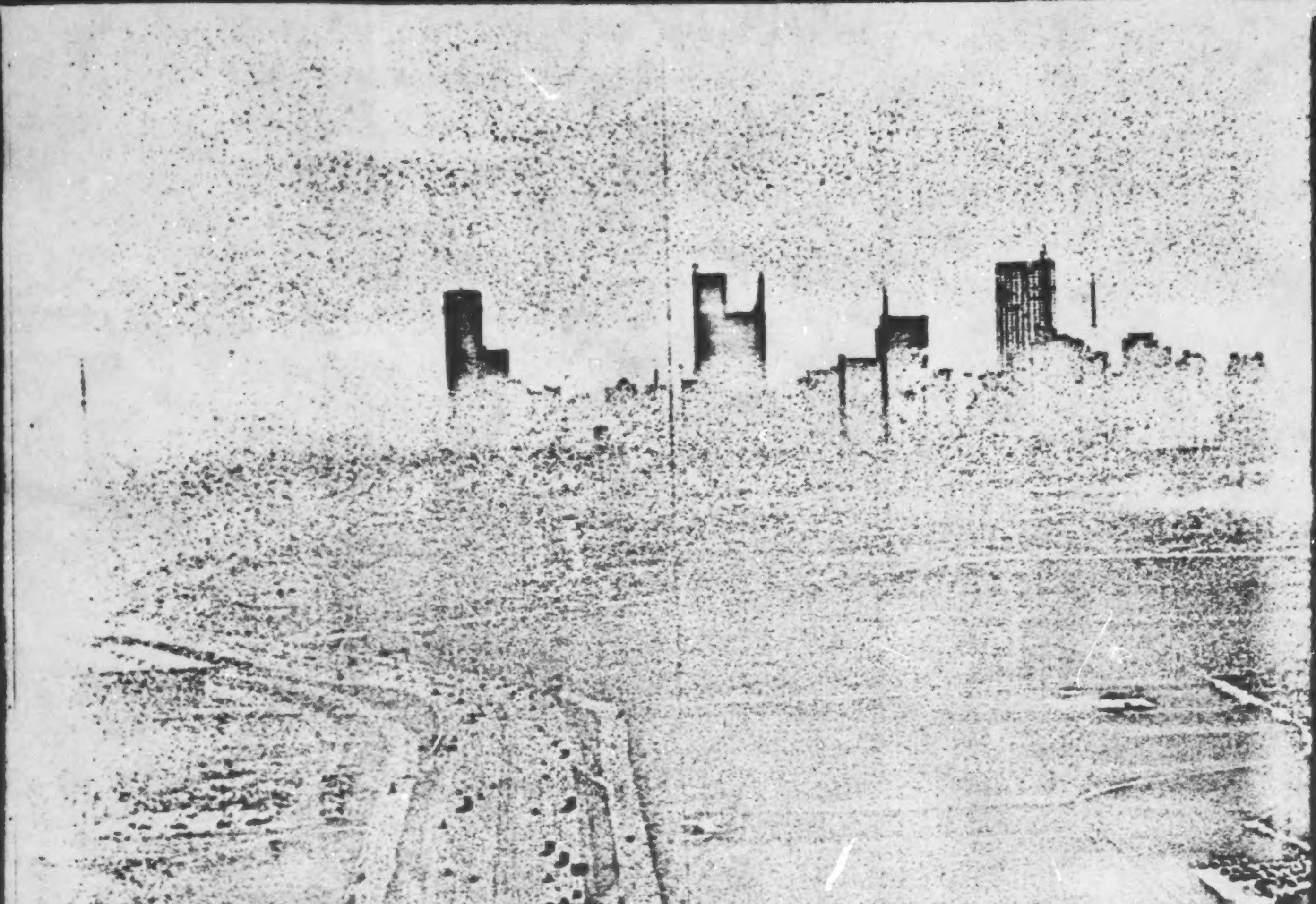
Are rivers, lakes and streams being thermally polluted in your locality? What evidence would you look for as an indication of this pollution? You might want to direct some students toward independent investigation at this point.

Before going on, do Self-Evaluation 5 in your Record Book.

GET IT READY NOW FOR CHAPTER 6

Several items needed in the chapter must be supplied locally. They are as follows:
Books of safety matches
Lids from baby-food jars
Small wads of cotton
Small pieces of wool cloth
Small pieces of Styrofoam
Notebook paper
Small pieces of cellophane tape
You will need dropper bottles (or containers and medicine droppers) for the turpentine.





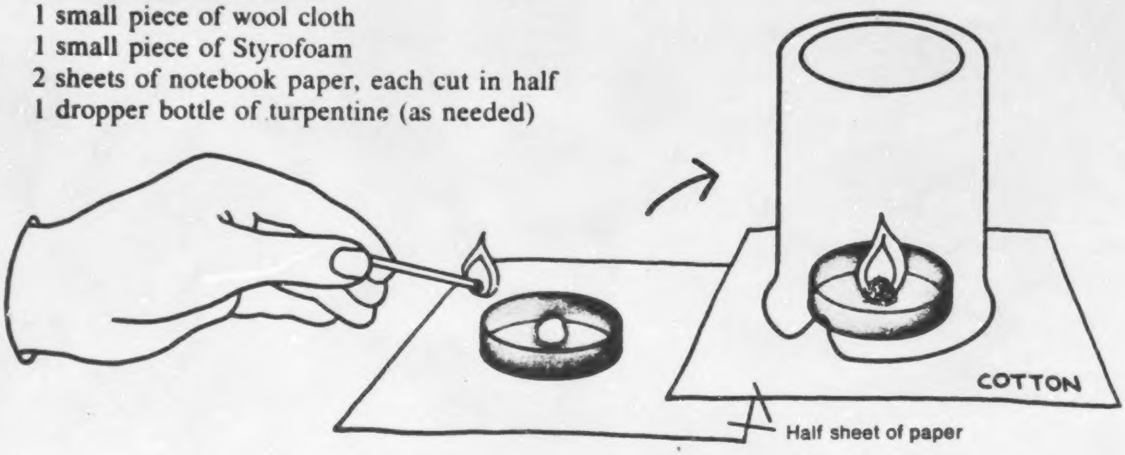
Chapter 6

Sick Air?

Excursion 6-1 is keyed to the chapter.

Air pollution, along with water pollution, is a major problem for our nation. Factories steadily belching smoke, trash dumps endlessly smoldering, and backyard incinerators burning intermittently have added millions of tons of waste materials to the atmosphere. What are these wastes like? And what effects do they have on the environment? To start finding out, you and a partner will need about 30 minutes and the following materials:

- 1 book of safety matches
- 1 600-ml beaker or large jar
- 1 small lid (from a baby-food jar)
- 2 small wads of cotton
- 1 small piece of wool cloth
- 1 small piece of Styrofoam
- 2 sheets of notebook paper, each cut in half
- 1 dropper bottle of turpentine (as needed)



ACTIVITY 6-1. Place a small wad of cotton in the center of the lid. Place the lid on a clean half sheet of notebook paper. Label the paper "Cotton." Light the cotton and invert the 600-ml beaker or jar over the lid.

EQUIPMENT LIST

Per student-team

1 600-ml beaker
1 baby-food jar lid
2 small wads of cotton
1 small piece of wool cloth
1 small piece of Styrofoam
2 sheets of notebook paper
3 small pieces of tape
1 hand lens (or microscope)
Safety matches

Per class

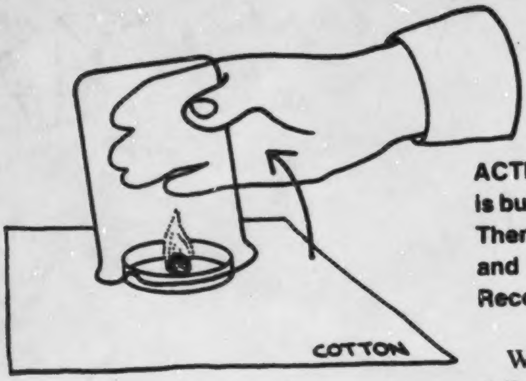
Dropper bottles of turpentine

CHAPTER EMPHASIS

The products of combustion are the major cause of air pollution.

MAJOR POINTS

1. Air pollution is a major problem for our nation.
2. The burning of flammable material can result in solid, liquid, or gaseous products in the air.
3. Some products of combustion are poisonous, even deadly.
4. Internal-combustion engines are a primary source of air pollution.
5. The steadily increasing number of family cars is causing a corresponding increase in air pollution.
6. Air pollution is a factor in certain diseases, in crop damage, in damage to livestock, and in general deterioration of many materials.
7. Valuable resources are wasted by air pollution.
8. Each person makes his own contribution to air pollution.



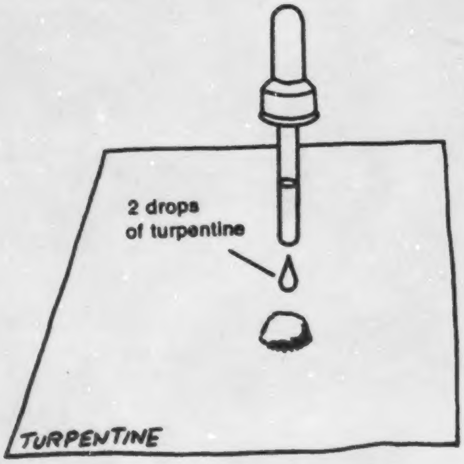
Students may experience some difficulties in getting the plain cotton and the wool to burn completely. In any case, there will be relatively little visible sign of the combustion except for the water on the beaker.

ACTIVITY 6-2. If the flame begins to die before the cotton is burned, lift the beaker slightly to let more air into the beaker. Then replace the beaker on the paper. Observe the beaker and its contents for two minutes after the flame goes out. Record all your observations in Table 6-1 in your Record Book.

When describing the products of burning, include the following: kinds of products; color; odor; whether it is a solid, liquid, or gas; and the appearance of whatever remains on the paper and lid after each burning. Be sure each piece of paper is labeled. Clean the lid and beaker after each burning and before doing the next part of the activity.

Arrange for ventilation during the burning activities. Open windows, provide a fan to blow the smoke out, or use a fume hood if available. You may want to have the activity done outside.

ACTIVITY 6-3. Put two drops of turpentine on a fresh wad of cotton. Label a clean half sheet of paper "Turpentine." Then repeat the procedure in Activities 6-1 and 6-2.



You may have to monitor the use of turpentine and Styrofoam. Some students enjoy watching the black soot form, and will want to use more than two drops of turpentine or a small piece (1 cm square) of Styrofoam.

Use the same general procedure for the wool cloth and the Styrofoam. Be sure to label and save each paper for comparison.

Table 6-1

Material Burned	Color and Odor of Smoke Produced	Description of Other Products of Burning	Other Observations
Cotton			
Turpentine and cotton			
Wool cloth			
Styrofoam			

If you want to determine the effects of burning samples of some other substances, be sure to get your teacher's permission first. You may then enlarge Table 6-1 and add your findings.

☐**6-1.** On the basis of your observations, which materials do you think would produce the most air pollution when burned?

Question 6-1 may seem easy at first. Deciding which substance produced the most smoke and the most unpleasant odor is not difficult. However, you may not be able to tell by looking and smelling whether or not harmful gases are being produced by some of the substances.

☐**6-2.** Which of the materials when burned produced the poisonous gas carbon monoxide?

You cannot, just by looking, tell what gases are produced from burning, except possibly for one. Yet even when something burns without producing black smoke, or any smoke at all, products are released. Of course, not all products are harmful.

You probably noticed that a liquid formed on the inside of the beaker when one or more of the substances were burned.

☐**6-3.** What gas, produced during the burning, probably formed the liquid in the beaker?

You may be able to guess that, in addition to water vapor, another gas was produced as each substance burned.

☐**6-4.** What gas product of most fires is used by plants in photosynthesis?

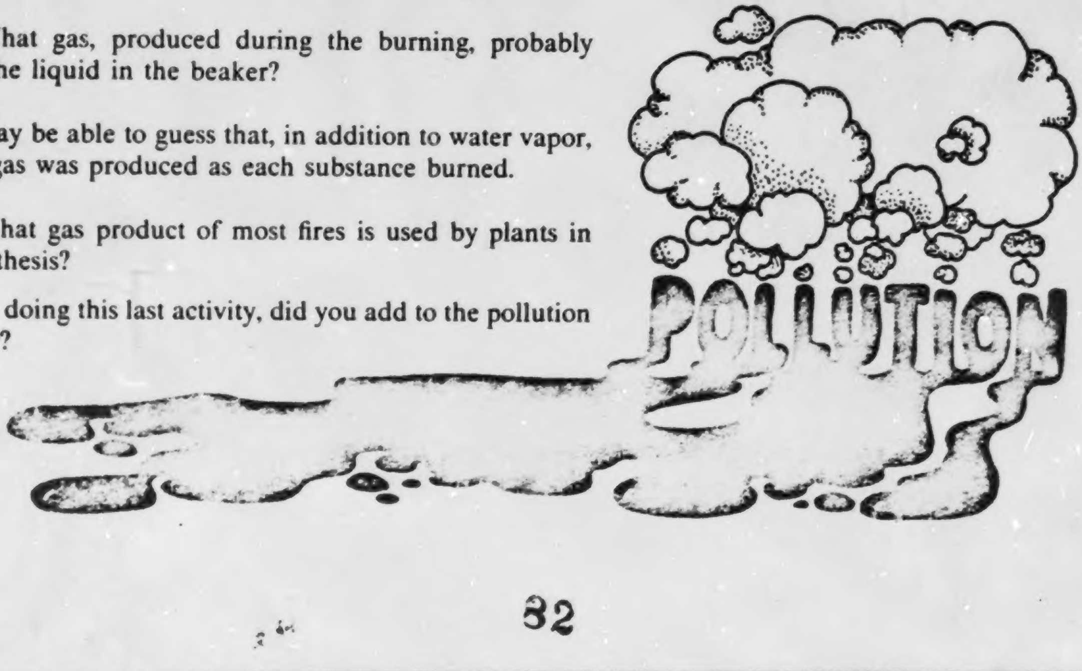
☐**6-5.** In doing this last activity, did you add to the pollution of the air?

Note the constraint for the student on obtaining your permission for further trials. You must exercise your judgment on the things that are tried.

6-1. On the basis of visual observations, either the turpentine or the Styrofoam would give the most air pollution, depending on the amount burned.

6-2. This is a good question to point up to the student that the colorless, odorless, and extremely dangerous carbon monoxide is very difficult to detect.

6-5. Yes. This question should help show that we all contribute to air pollution. It is not something done by "bad guys" only.



Americans place about 190 billion kilograms of waste materials into the air each year. Five sources account for most of the nationwide air pollution problem. Table 6-2 shows what these sources are and identifies some of the chemical wastes from each source.

Table 6-2

	POLLUTANTS (billions of kg)					
Source	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides	Sulfur Oxides	Solid Particulates	Total by Source
Transportation (cars, truck, buses, etc.)	58.1	15.9	6.9	0.3	1.1	82.3
Electrical power plants and heating	1.7	0.6	6.0	20.6	8.3	37.2
Industry	9.6	3.2	0.2	6.5	6.9	26.4
Refuse disposal	6.9	1.4	0.5	0.1	0.9	9.8
Misc. (forest fires, etc.)	15.2	7.4	1.6	0.6	8.7	33.5
Totals	91.5	28.5	15.2	28.1	25.9	189.2

☐**6-6.** What source produces the greatest amount by weight of air pollution?

☐**6-7.** What source produces the most carbon monoxide?

☐**6-8.** If one wanted to reduce the solid particulates in the air, which sources would he have to confront?

☐**6-9.** What are the two main sources of sulfur oxides?

The information in Table 6-2 applies to the entire United States. There may be major differences in the sources of pollution products in a particular region. Perhaps you are not familiar with the types of pollutant products identified in Table 6-2. If so, the information in Table 6-3 should be helpful.

☐**6-10.** Which types of air pollutants listed in Table 6-2 directly affect man's health?

6-10. All the air pollutants listed in Table 6-2 directly affect man's health.

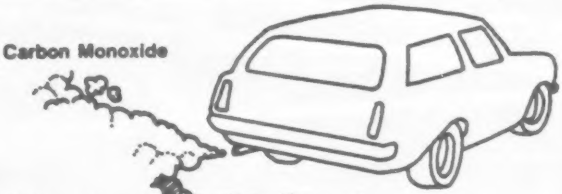
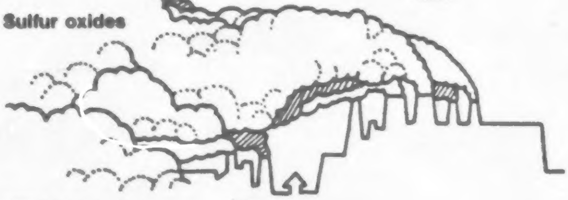
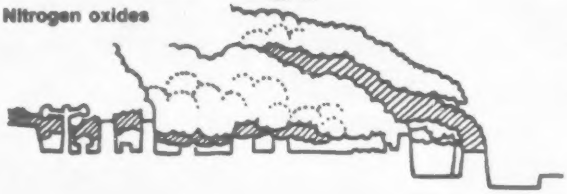
POLLUTANT	DESCRIPTION
Carbon Monoxide 	This colorless, odorless gas, is often found in tunnels, closed garages, and near heavy traffic. It is produced when carbon-containing fuels are incompletely burned. Carbon monoxide reduces the ability of blood to carry oxygen. Large amounts are fatal; small amounts cause dizziness, headaches, fatigue, and slowed reactions.
Sulfur oxides 	These poisonous gases come mainly from the burning of coal and oil containing the element sulfur. They irritate the eyes, nose, and throat; damage the lungs; kill plants; destroy metal; and reduce visibility.
Nitrogen oxides 	Burning fuels produce most of these gases. They produce a smelly, dark haze that irritates the eyes and nose.
Hydrocarbons 	These result mainly from unburned fuels during combustion. However, large amounts also are produced as tires wear. Hydrocarbons are known to produce cancer. Hydrocarbons react with nitrogen oxides and sunlight to produce smog.
Solid particulates 	There are many forms of solid matter in the air—dust, smoke, soot, ash, etc. These particles may stay suspended or settle to the ground. They dirty many objects and darken the sky. Solid particles interfere with normal breathing.

Table 6-3

PROBLEM BREAK 6-1

How much air pollution is occurring in your own neighborhood or community? You can get a rough idea by simple observation. As you are on your way to and from school, observe any smoke you see. Try to locate its source. Find out what kind of material is being burned and the sort of smoke produced. Keep a record of your findings in your Record Book.

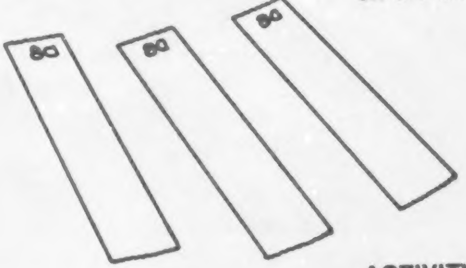
After a period of time, you may wish to discuss the results with some of your classmates. You may be surprised at how much smoke there is in your area when you start looking for it! But don't forget, not all air pollution is visible.

As you've seen, gases are not the only product of burning; various particles also result. In addition, dust and pollen add to the particulate content of air. Use the method of studying particulate pollution shown in Activities 6-4 and 6-5.

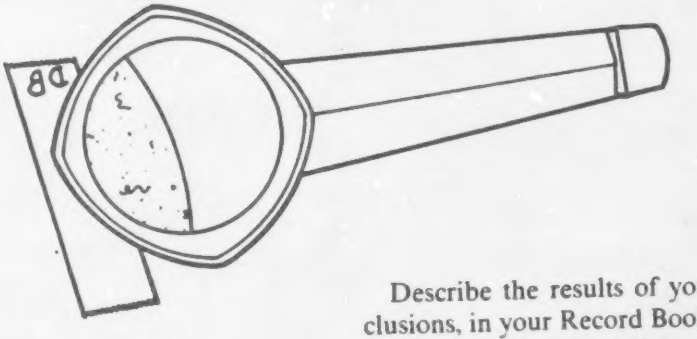
The pieces of tape in Activities 6-4 and 6-5 will collect particles at a rate that varies with location. If the building is air-conditioned, there will be less deposited. It probably will require at least two days in any case.

An alternative method for collecting particulate pollution consists of coating several plastic strips or glass microscope slides with a thin layer of grease or petroleum jelly. You might even want to try trapping particles outdoors.

ACTIVITY 6-4. Place small pieces of tape (with the sticky side up) in two or three places around the room. Put your initials on the smooth side of each piece.



ACTIVITY 6-5. After a period of time, examine the strips with a hand lens or microscope to see what particles have collected.

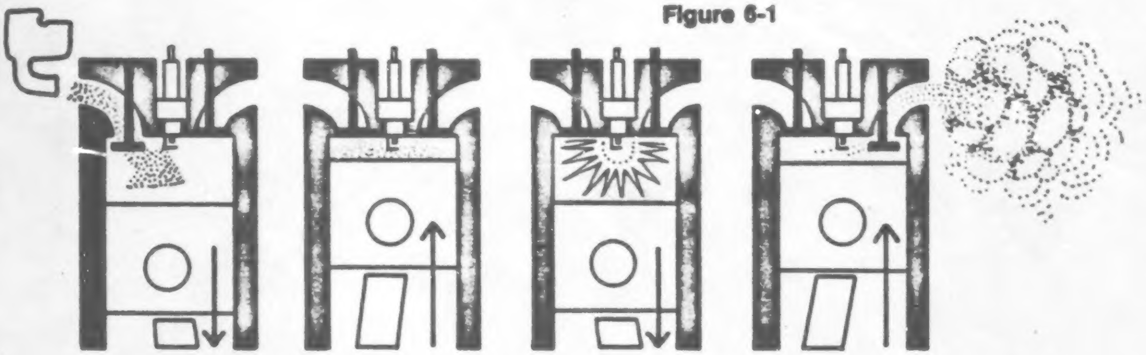


Describe the results of your investigation, and your conclusions, in your Record Book. You may want to try to locate the sources for the particles you collect.

From your activities so far in this chapter, you have seen that large amounts of air pollution can result from the burning of even small amounts of materials.

As you may know, automobiles and air pollution are closely related. Most cars have internal-combustion engines that operate somewhat like a small furnace. Chemical energy from burning fuel inside the engine provides the mechanical energy that moves the car. See Figure 6-1.

Figure 6-1



1. Intake 2. Compression 3. Combustion 4. Exhaust

The internal-combustion engine is considered by some to be the single most important contributor to air pollution. Is such a statement justified? You can decide for yourself as you study the next two pages.

About 80 percent of American families own cars. And about 30 percent of families own two or more cars. There are also millions of trucks, buses, motorcycles, and taxis. Altogether, there are about 100 million motor vehicles in the United States today. See Tables 6-4 and 6-5.

You might suggest graphing some or all of the data in Tables 6-4 and 6-5 as an aid to answering questions 6-11 through 6-14. Graphs can be very helpful in showing trends.

Table 6-4

MOTOR VEHICLE REGISTRATIONS (millions)

			Date		
Type of Vehicle	1950	1955	1960	1965	1970*
Passenger cars, taxis	40.3	52.1	61.7	75.2	84.4
Trucks and buses	8.8	10.5	12.7	15.1	18.1
Motorcycles	0.4	0.4	0.6	1.4	2.5
Total	49.5	63.0	75.0	91.7	105.0

**Number of vehicles estimated*

AUTOMOBILE OWNERSHIP (By Year)*

	1950	1955	1960	1965	1970
No. of families (millions)	45.2	49.1	53.4	58.5	63.7
Families owning automobiles (%)	59	70	77	79	80
a. Families owning one automobile (%)	52	60	62	55	50
b. Families owning two or more automobiles (%)	7	10	15	24	30

* *Excluding Alaska and Hawaii; figures for 1970 estimated*

Table 6-5

Use the information in Tables 6-4 and 6-5 to answer the following questions.

☐**6-11.** What was the increase in the total number of motor vehicle registrations between 1950 and 1970?

☐**6-12.** What was the increase in the total number of families owning cars between 1950 and 1970?

☐**6-13.** Based on the increase in the *number of cars* and the *number of families owning cars*, what do you predict will be the total number of cars in 1975?

☐**6-14.** What do you predict will be the percentage of families in 1975 that own two or more motor vehicles?

6-11. 55.5 million
6-12. 18.5 million
6-13. Cars, 92 million; total motor vehicles, 118 million
6-14. 35%

Note that the number of cars and the number of families owning cars are increasing at a rapid rate, but the percentage of families owning automobiles apparently is leveling off around 80%. This is because of the rapid increase in the number of families in the United States.

Remember, automobiles are powered by combustion. In this way, a motor vehicle is like a match or like a human: each one contributes its own output to the air, and each one requires inputs from the environment.

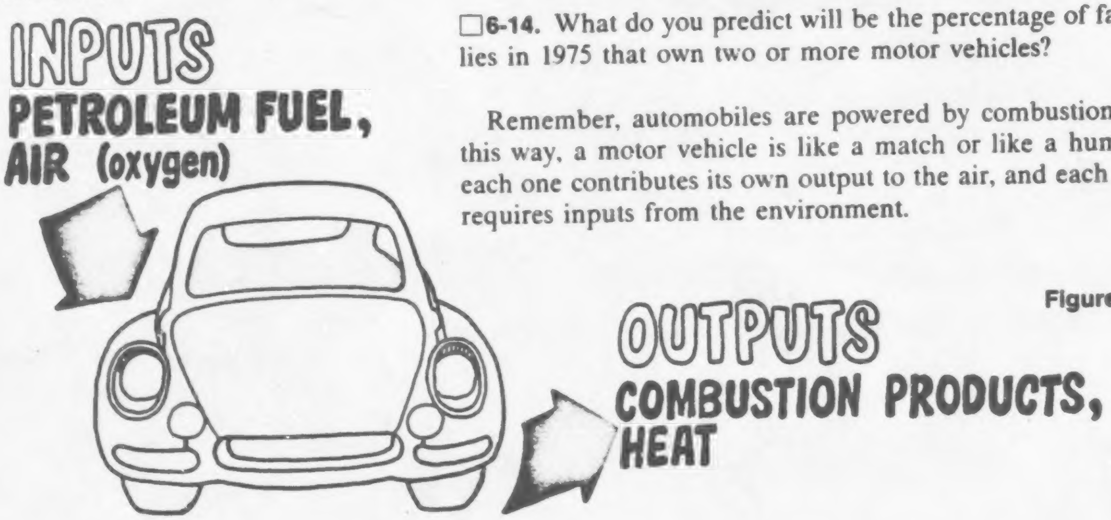


Figure 6-2

Study the data in Table 6-6 to see the effects a motor vehicle has on the surrounding atmosphere.

Table 6-6

AVERAGE OUTPUT OF AIR POLLUTANTS FROM MOTOR VEHICLE OPERATING AT ABOUT 40 km/hr

Source	Pollutant	Quantity of Output (g/liter of fuel)
Gasoline engines	Carbon monoxide	284.9
	Nitrogen oxides	22.2
	Hydrocarbons	15.8
	Solid particulates	1.3
	Sulfur oxides	1.0
Diesel engines	Hydrocarbons	21.6
	Solid particulates	13.3
	Nitrogen oxides	12.0
	Carbon monoxide	7.1
	Sulfur oxides	4.8

☐**6-15.** According to Table 6-6, what are the three most abundant pollutants from gasoline-powered vehicles?

☐**6-16.** What are the three most abundant pollutants from diesel-powered vehicles?

☐**6-17.** Which type of engine produces more solid particulates?

☐**6-18.** Estimates show that in a city of about 50,000 people, at least 76,000 liters of gasoline are burned by automobiles each day. According to the data in Table 6-6, how many grams of carbon monoxide would be added to this city's atmosphere each day?

It has already been said that carbon monoxide (CO) is a poisonous gas. The fact is, it can be a killer. Examine Figure 6-3.

Advanced students might be interested in "personalizing" the problem, using these data. If they can determine the weekly mileage that the family car travels, or the amount of gasoline consumed, they can arrive at a figure for the pollutants for which their car is responsible. For example, suppose the family car travels 180 miles (300 km) per week. At an average, for city driving, of 15 miles per gallon (6.4 km per liter) the amount of gasoline used would be about 46 liters. Using Table 6-6, the grams of pollutants can be found.

6-18. 21,652,400 g

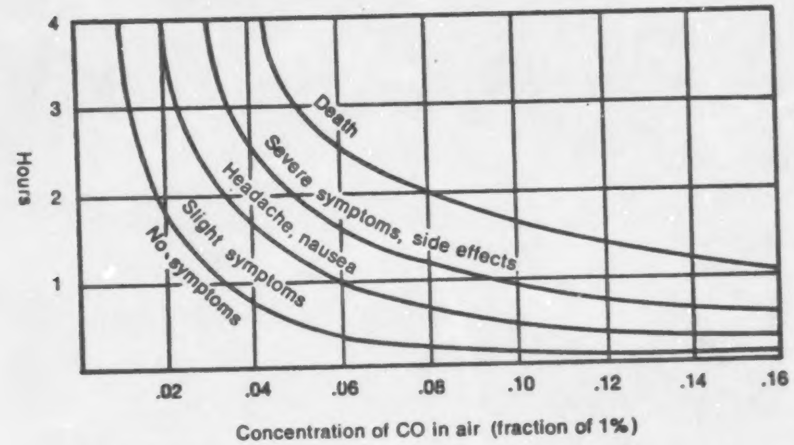
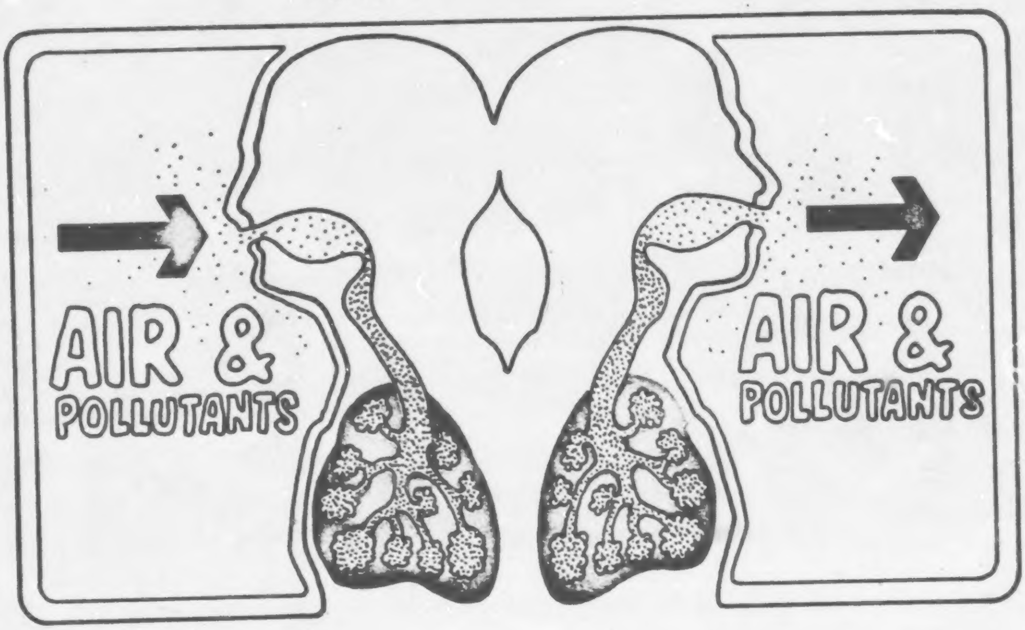


Figure 6-3

6-19. Approximate times from Figure 6-3 would be 2½ hours; 1 hr 25 min; just over an hour.

☐**6-19.** How long would a person have to be exposed to CO before death occurs if the concentration of the gas in the air is 0.06%? 0.12%? 0.15%? Man, as an input-output system, is seriously affected by air pollutants.

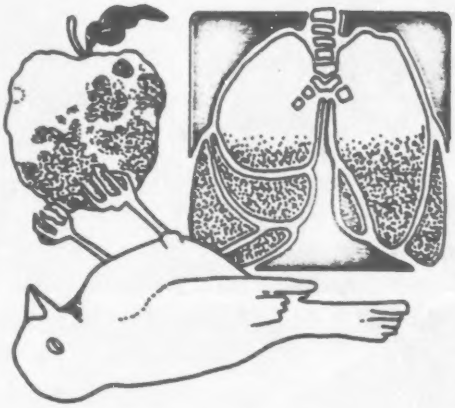
Figure 6-4

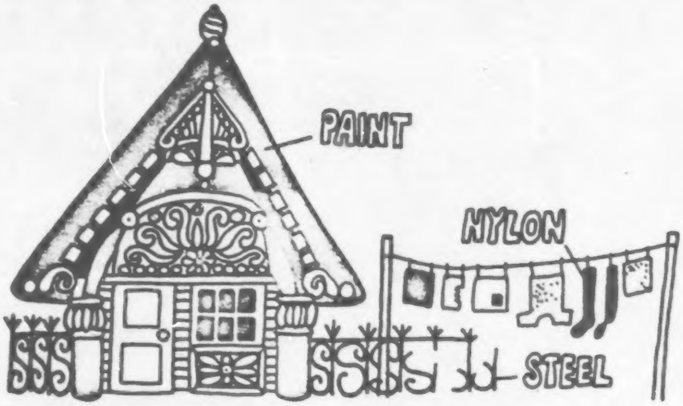


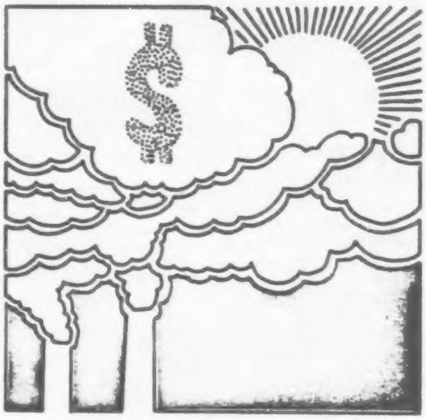
Anything that injures lung tissue is a hazard to life. Carbon monoxide and other air pollutants have been found to change some lung tissue. These changes in tissues may produce lung diseases such as bronchitis and emphysema—diseases that were rare twenty-five years ago. Much needs to be learned about the causes of these diseases. However, evidence indicates that air pollutants are at least partly responsible for them.

There are other bad effects that result from air pollution.

Annual crop damage from air pollution is estimated at over $6,000,000,000. Thousands of domestic and wild animals are weakened or killed outright. Exact data on human death and disease are lacking, but it is clear that air pollution is especially dangerous for people with heart disease, asthma, emphysema, anemia, etc. Lung cancer is found twice as often in air-polluted cities as in rural areas.

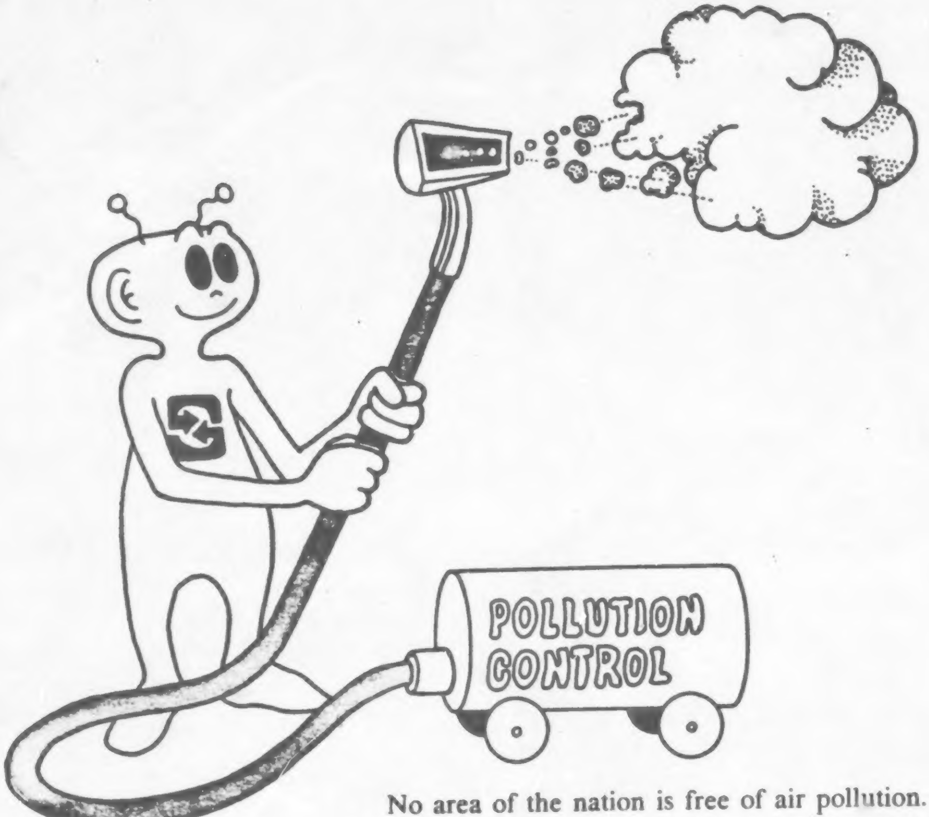






Polluted air discolors and damages clothing, automobiles, and buildings. A major maintenance factor in polluted areas is the replacement of discolored and peeling paint. Steel deteriorates two to four times faster in air-polluted cities than in rural areas. Dirty air deteriorates rubber, glass, leather, nylon, paper, and even stone.

Incomplete combustion of fuels not only pollutes the air but wastes valuable resources. For example, more than $300,000,000 worth of sulfur is wasted annually. Industries are working hard on ways of reclaiming and using "waste" products. Pollution causes higher lighting and heating bills. For example, it is estimated that in Chicago on some days air pollution reduces sunlight by 40 percent.



No area of the nation is free of air pollution. Therefore, air pollution is everyone's problem. And everyone contributes to it. It is estimated that air pollution costs the United States about $13,500,000,000 a year.

☐**6-20.** How much is your "share" of this cost? (Hint: Assume a U.S. population of approximately 210,000,000.)

In the last several chapters, you've studied air and water pollution. Both are particular problems in cities and towns. Yet neither form of pollution respects city limits. Air and water flow from one region to another, often carrying pollutants long distances from their source.

Questions 6-21 and 6-22 are good ones for discussion. Students may have to be urged a little to think of all the ways that they pollute the air.

☐**6-21.** List all the ways that *you* contribute to the problem of air pollution.

☐**6-22.** Describe how your contributions to air pollution might be reduced or eliminated.

Serious air-pollution crises have occurred in many U.S. cities and in other cities around the world. One of the most disastrous situations occurred in London, England. **Excursion 6-1** describes that crisis and helps explain how it happened.

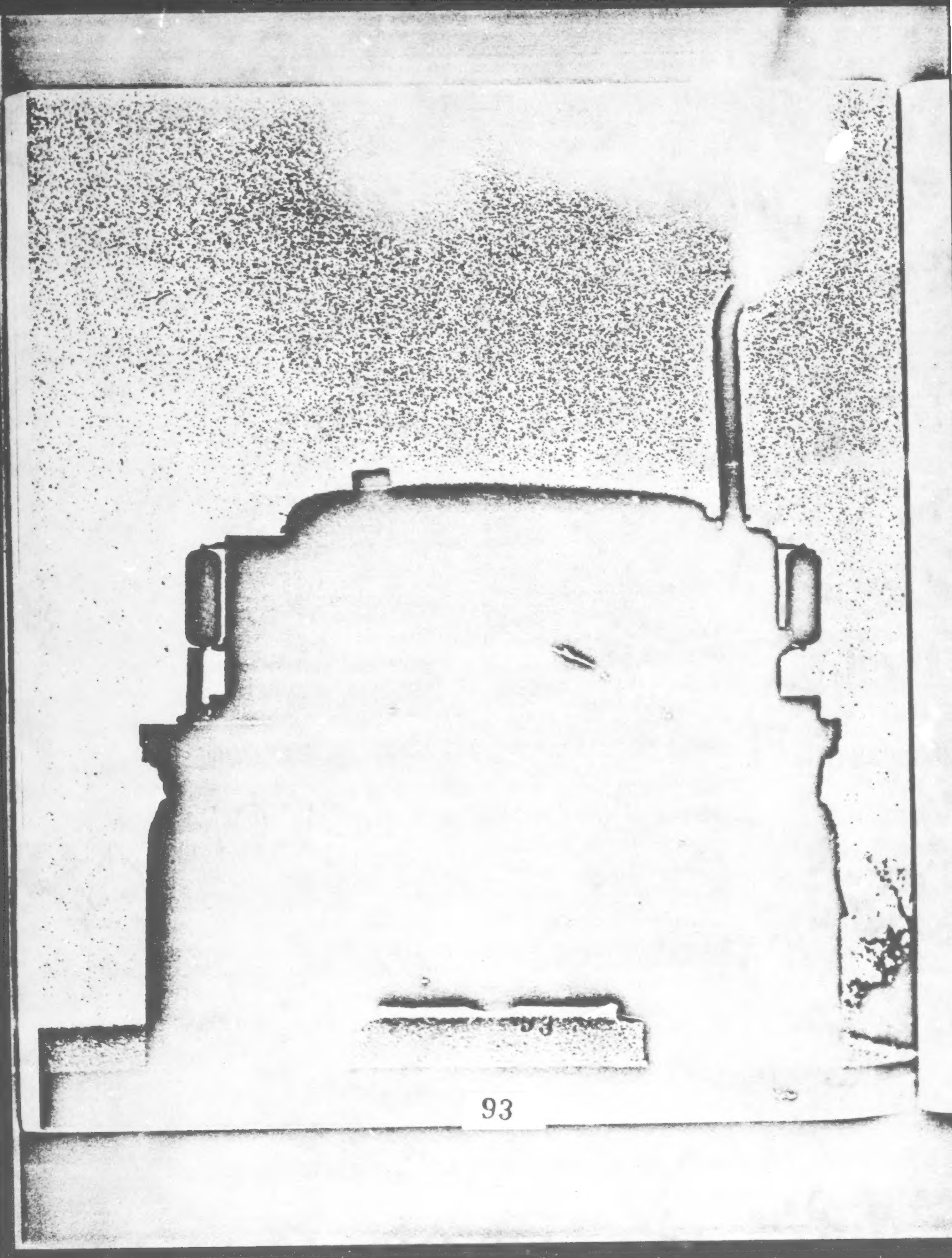
Fifty years ago, even fifteen years ago, few people were worried about the effects of pollution. Why is concern for the input-output relationship between man and his surroundings suddenly so important? Chapter 7 deals with this question by looking at what is happening to the world population.

Before going on, do Self-Evaluation 6 in your Record Book.

◀ EXCURSION

Excursion 6-1 is an interesting one for extension and general interest. It introduces the idea of a temperature inversion. It requires no equipment and could be done at home.

No materials need to be prepared for Chapter 7.



EQUIPMENT LIST

None

The Environment Throws a Curve

Excursions 7-1, 7-2, and 7-3 are keyed to this chapter.

Ever since man appeared on the earth, his activities have affected the input-output balance of living things and their surroundings. His most recent effects are perhaps the most outstanding. Lands, once forested, are now covered over with concrete and steel. Many bays, rivers, and lakes, once clear and filled with life, have shores spoiled by oil spillage and refuse. City air, at first clear, then hazy, is now smog-filled.

CHAPTER EMPHASIS

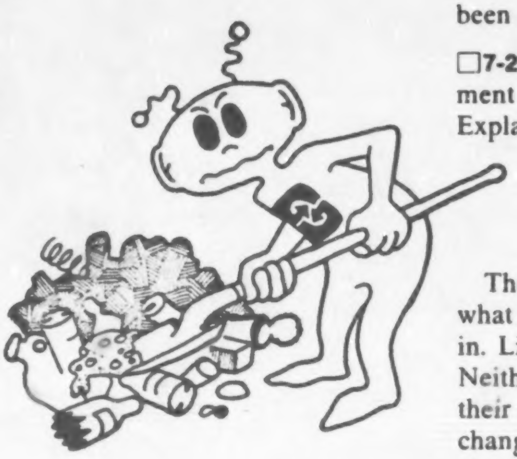
Rapid increase in the human population is causing many problems on the earth.

Chapter 7

MAJOR POINTS

1. Population curves of living things are typically S-shaped, with a slow, then a rapid, increase followed by a leveling off.
2. The rapid increase in population is called a population explosion.
3. Variables that could limit the population level, and cause the leveling off, are these:
   a. presence of disease organisms
   b. presence of wastes and poisons
   c. amount of food and needed gases
   d. availability of space
4. When number of births equals number of deaths, the population remains constant.
5. The population curve for man has not yet leveled off.
6. Scientists believe the size of man's population is limited by the same environmental factors that limit the populations of other living things.

Chapters 7 and 8 have little or no laboratory experiments or activities. Instead, the student uses the background that has been built up in the earlier chapters to solve practical environmental problems. Graphs are used to point out some of the factors. Students may feel that these chapters are not as important as the others. This should not be the case, and you may have to use your influence to counteract this feeling.



☐**7-1.** Why have man's greatest effects on the environment been the most recent ones?

☐**7-2.** Do you predict man's future effects on his environment will be greater than, or less than, those up to now? Explain your prediction.

7-2. Accept the student's prediction. The explanation, however, should have some reasonable basis other than just a feeling of optimism or pessimism.

The effect of people on their surroundings depends upon what they take from the environment and what they put back in. Living things cannot avoid changing their environment. Neither can groups of living things avoid being changed by their environment. The larger the size of the group, the more change it will produce. How has the size of the human group changed, and what will be the result of that change?

Table 7-1 shows what has happened to the world population since 8000 B.C. Plot this information on the grid in Figure 7-1 of your Record Book. Then draw a best-fit line.

You may want to check the graphs of several students to see that the data have been plotted correctly. Note also that it should be a best-fit (smooth) line.

Table 7-1

WORLD POPULATION CHANGES

Date	Population (millions)*
8000 B.C.	5
4000 B.C.	75
2000 B.C.	150
Birth of Christ	250
A.D. 1650	500
A.D. 1830	1,000
A.D. 1930	2,000
A.D. 1960	3,000
A.D. 1970	3,600
A.D. 1975	4,000
A.D. 2000	7,500

* *Estimated population*

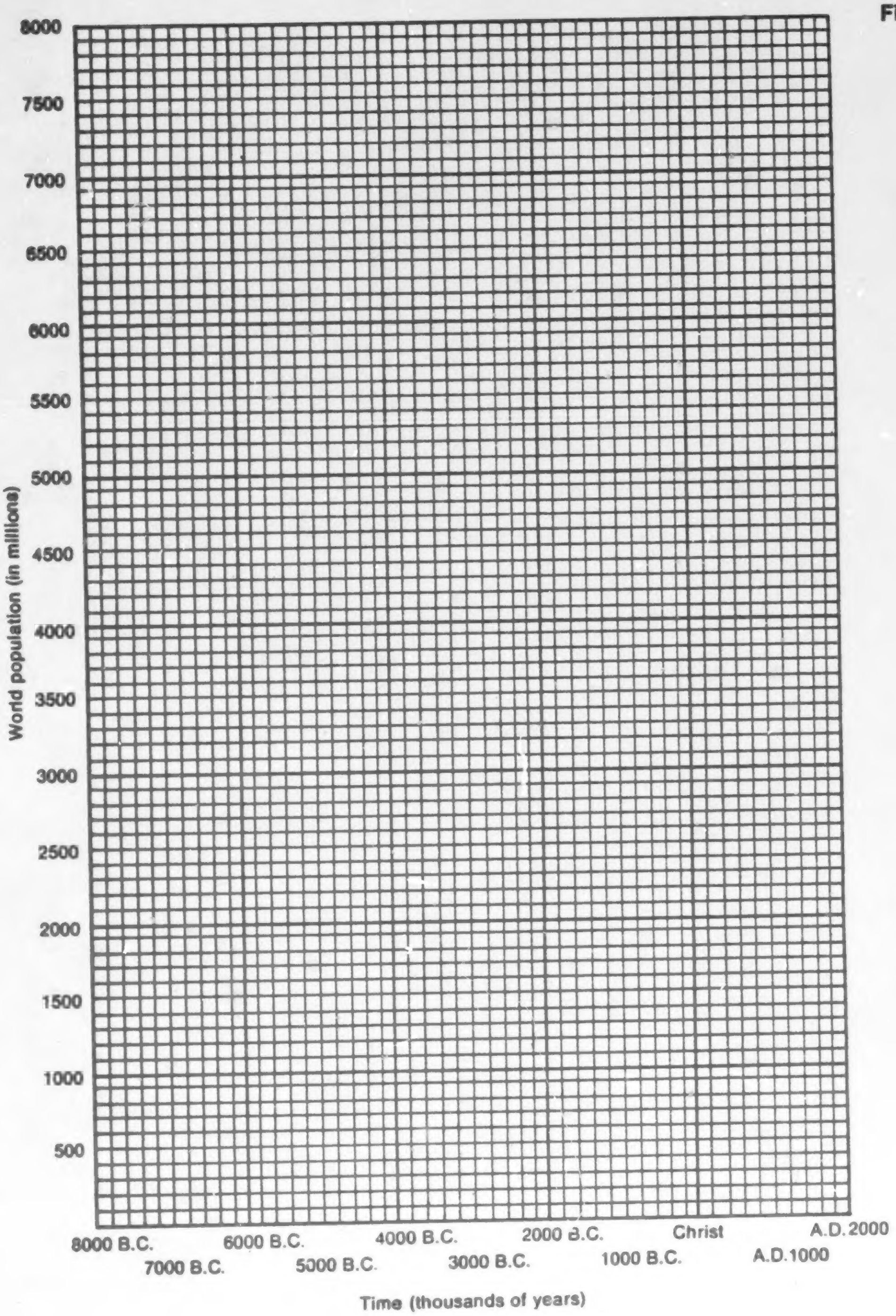

8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
World population (in millions)
8000 B.C.
7000 B.C.
6000 B.C.
5000 B.C.
4000 B.C.
3000 B.C.
2000 B.C.
1000 B.C.
Christ
A.D.1000
A.D.2000
Time (thousands of years)

Figure 7-1

☐**7-3.** According to your graph, what will the world population be by 2020?

You probably had trouble with the last question. It's not easy to answer from the graph. If the graph you drew in Figure 7-1 is a good one, the line near the right-hand side should have been about straight up! This rather startling prediction about population growth has led to the term *population explosion.* The population increase is occurring at an "explosive" rate.

7-4. The student answers should prove interesting. It probably should be pointed out, however, that there is no unanimity among scientists on the question of how high the human population can go.

☐**7-4.** Can the size of the world population of humans continue to increase from now on?

Perhaps you need more information to answer question 7-4. For example, is the human population explosion typical of other living organisms? Take a look at population growth in some other animal.

One common but very tiny animal frequently used in experiments is the paramecium. It reproduces by dividing. One animal divides to become two (Figure 7-2). Each of the new animals divides again, making four. Because parameciums live and reproduce in water, their population growth can be observed easily.

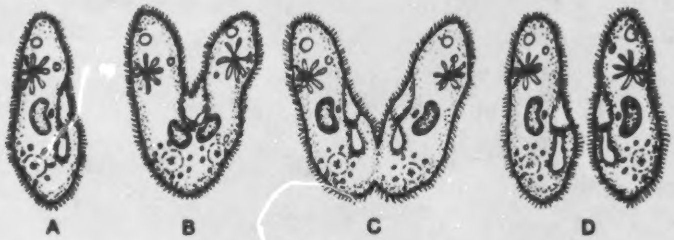


Figure 7-2

In one investigation, 0.5-ml samples of water were taken daily from a container in which there was a well-fed paramecium population. A microscope was then used to count the number of organisms in each 0.5-ml sample. Table 7-2 contains the results of thirteen days of investigation. Plot this information on the grid in Figure 7-3 in your Record Book and draw a best-fit line.

The paramecium population in the container certainly grew rapidly within one week. In those few days, it became eighty times larger than at the start.

	TIME (days)													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of parameciums in 0.5-ml sample	5	12	30	75	150	260	340	405	440	450	455	445	460	450

Table 7-2

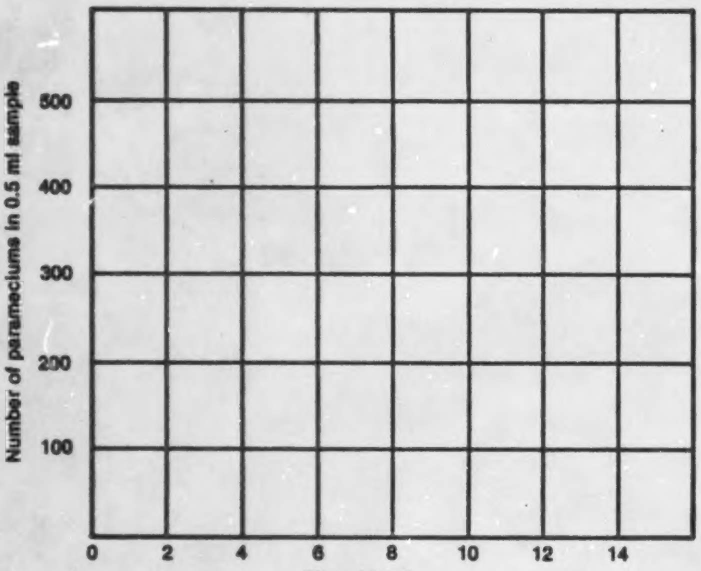


Figure 7-3

☐**7-5.** According to the graph, is the rate of population increase a constant?

☐**7-6.** What do you predict the population will be by the beginning of the fourteenth day?

☐**7-7.** On what day did the number of births first about equal the number of deaths in the population? How do you know?

7-6. Between 445 and 460

7-7. The probable answer is either day 9 or 10. This should be evident from the figures (no increase in total population) and from the graph (leveling off of the line).

If you completed Figure 7-3 successfully, the shape of the curve should have reminded you of the letter S. This S-shaped curve has been found in population studies of many plants and animals. Because of this, it is often called a population curve. Figure 7-4 shows a typical population curve.

The letters A and B have been added to identify certain points on the curve.

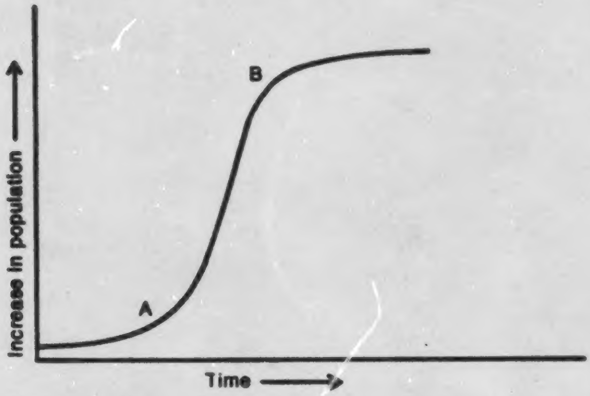


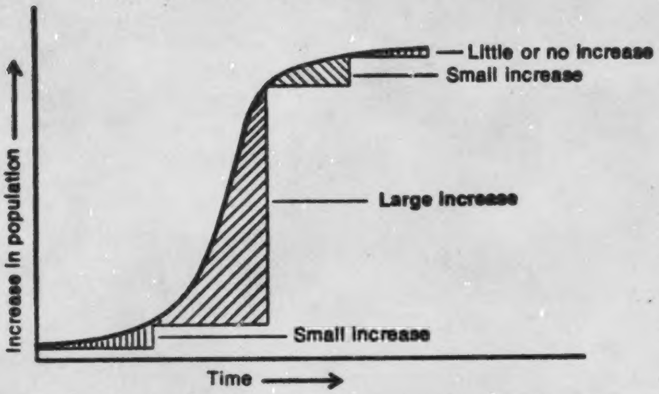
Figure 7-4

☐**7-8.** What happened to the size of the paramecium population up to point A?

☐**7-9.** What happened to the population during that part of the graph between points A and B?

☐**7-10.** What happened to the rate of population increase from point B on?

Figure 7-5



As you can see, there is first a small, then a great, increase in the population size. This sharp increase is followed by a leveling off in the rate of population change. Finally, the size of the population stays about the same. This is illustrated in Figure 7-5.

☐**7-11.** What variables would cause the population curve to level off after point B?

☐**7-12.** How does the curve in Figure 7-1 (the one for the human population change) differ from the typical population curve (Figure 7-4)?

In your answer to question 7-11, you may have suggested several variables that could limit the population level. Your list may have included some of the following:

1. The presence of disease organisms
2. The presence of wastes and poisons
3. Amount of food and needed gases
4. Availability of space for the organism

The environment cannot support more life than it can feed. Neither can it continue to support life if wastes and poisons become too concentrated. The greater the size of the population, the more the organisms are crowded together. Thus, accumulation of wastes increases.

Although students may not have realized it, the activities in Chapter 3 that used yeast could have been the beginning of a population study. These microorganisms, when supplied with food, (powdered milk, containing sugar) multiply. However, as the sugar is consumed, it is converted to alcohol by the process of fermentation. This alcohol serves as a poison, and the yeast population, if the experiment were allowed to continue, would stop multiplying and in fact would decrease.

7-12. The human population curve has not leveled off, and continues to increase at a high rate.

Poor nutrition means a weakening of the living organism. Thus, chances of survival are reduced. Crowding and accumulation of wastes and poisons increase the likelihood of early death of the organism through spread of disease. Eventually, because of the input-output between environment and organisms:

Excursion 7-1, "The More the Merrier?" is for enrichment purposes. It will give some ideas about the effect of overcrowding on animals.

Number of births in the population	EQUALS	Number of deaths in the population

EXCURSION

Excursion 7-1 describes an important experiment that was done to study population increase of mice. The excursion may give you an idea of how you might set up your own population study.

What then does all this mean for the human species? Man is an organism, and the population curves for organisms seem to have a similar shape. How much of the S-shaped population curve is complete for man? (Refer to your graph from Figure 7-1 in your Record Book.)

☐**7-13.** Does the rate of human population growth seem to be leveling off?

☐**7-14.** Does the total population predicted for the year 2000 suggest that there will be a leveling off of the curve by that time?

☐**7-15.** It is predicted that the 1970 world population will be doubled by the year 2007. Does your graph in Figure 7-1 support that prediction?

Apparently the curve in your graph is only a part of the typical population curve. The human population grew very slowly at first. Now it is growing rapidly. The question many people are asking is, "When will the human population level off?"

7-16 Again, there can be a wide divergence of opinions on the increase of world population. Man, with his ingenuity, is able to adapt to conditions that normally would serve to limit the growth. Disease is conquered by medical practices; increased food production is accomplished by improved farming. But some factors have not yet been brought under control.

☐**7-16.** Give as many reasons as you can for why you think the world population can or cannot continue to increase indefinitely.

Scientists believe man is controlled by the same environmental factors that limit the populations of other living things. Overcrowding, famine (lack of food), and pollution perhaps are some of these factors.

Man's output has become the environment's input back to him. How will these inputs affect his numbers?

Some people believe man can escape an overpopulated planet before it is too late. If you are one of these, you'll want to look at **Excursion 7-2**, "Escape into Space."

Some folks argue that there is only one way to stop overpopulation. **Excursion 7-3** illustrates their ideas.

Before going on, do Self-Evaluation 7 in your Record Book.

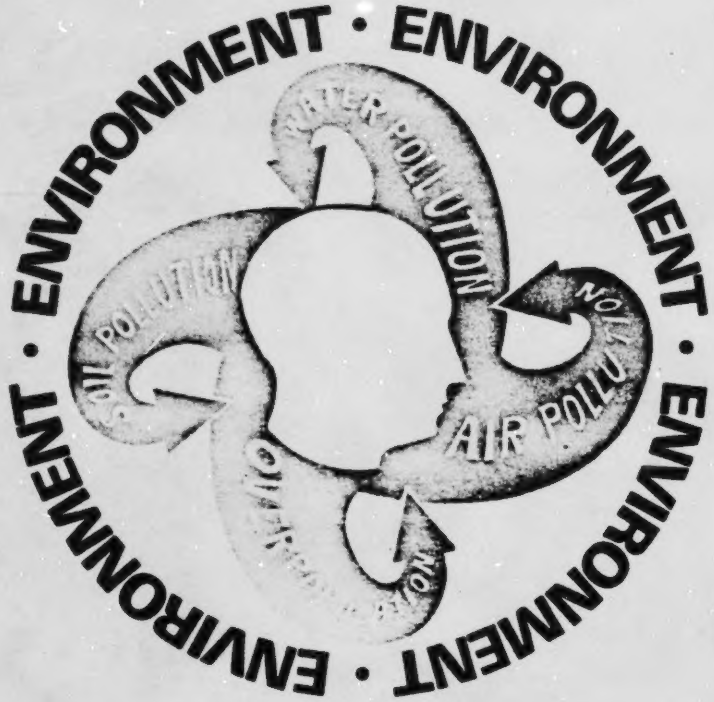
Excursion 7-2 is fairly rigorous and may be completed only by the more ambitious students. Everyone can get something from it, however, and should enjoy the surprise ending.

Excursion 7-3 is an interesting approach to a controversial subject. It is for enrichment purposes.

No materials need be prepared for Chapter 8.

◀ EXCURSION

◀ EXCURSION


ENVIRONMENT • ENVIRONMENT • ENVIRONMENT • ENVIRONMENT •
WATER POLLUTION
AIR POLLUTION
SOIL POLLUTION
POLLUTION

EQUIPMENT LIST

Watch or clock with second hand

CHAPTER EMPHASIS

The solutions to environmental problems are usually difficult and require the consideration of many points of view.

Facing Real Problems

Chapter 8

Excursion 8-1, for enrichment, is keyed to Problem Break 8-5 in this chapter.

MAJOR POINTS

1. Simply counting all the individuals in the population by ordinary methods would be a tremendous (and neverending) job.
2. Making just decisions about problems related to the environment is a difficult job. It requires (a) seeing all sides of the problem, (b) weighing all the factors involved, (c) considering the welfare of all people, and (d) courage and common sense.
3. Each major problem is composed of many smaller ones. To find a solution to a large problem, the smaller ones must first be solved.

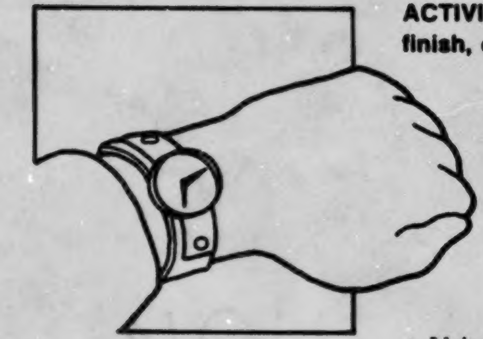
This final chapter could be the most stimulating and thought-provoking one for your students. Hopefully, they will be able to apply what they have learned in earlier chapters. The problem breaks are designed to introduce them to a variety of current issues centered around environmental problems.

For most of us, it is hard to believe the earth will ever be overcrowded. Four billion people—earth's present population—sounds like a lot, but can you imagine what such a number means? If you are like most people, numbers of that size don't mean much. Even the number 1,000,000 is more than most people can manage.

Perhaps the following activity will help you appreciate the size of the world population and the rate at which it is changing.

Suppose you had to count all the new people added to the world's population. You can find out how good you would be at this job by seeing how long it takes you to count a few people—all those in your classroom. You will need a watch or timer.

23456789
two four
one
three
50784
13542
372



ACTIVITY 8-1. Note the time when you begin, and when you finish, counting all the people in the room.

Using the following formula to get your people-counting rate:

$$\text{People-counting rate} = \frac{\text{Number of people counted}}{\text{Time (seconds)}}$$

8-1. Insist on the correct units being given (number counted/second).

☐**8-1.** What is your people-counting rate?

Even though your rate may be faster, let's suppose you counted one person every second.

☐**8-2.** How many people could you count in one minute? in one hour?

☐**8-3.** Suppose you counted at that same rate for one day (24 hours). How many people would you have counted? (Sorry, no time out for meals, rest, or sleep.)

8-4. 86,400 × 365, which is 31,536,000 people

☐**8-4.** Suppose you worked 24 hours per day for the next year (365 days). How many people would you have counted by the end of the year?

8-5. 1,892,160,000 people

☐**8-5.** Suppose you put in the next 59 years counting people at the same rate (24 hours per day with no breaks). How many people would you have counted at the end of 60 years?

After 60 hungry and thirsty years of hard work with no sleep, you could have counted less than two billion people. During that period, the world's population would have gone up by more than two billion. This means that you would have more people still to count than you started with.

To measure gains in population, you have to know more than just how many people are born. You also need to know how many die.

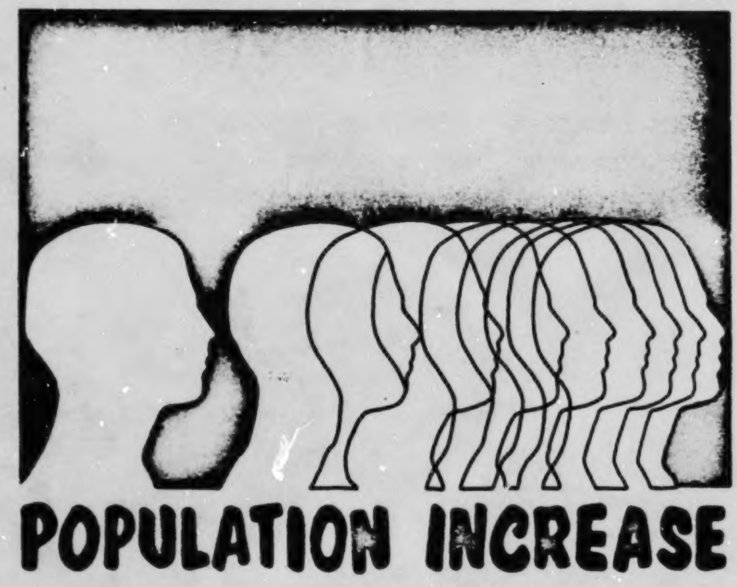
☐8-6. Complete Table 8-1 in your Record Book.

Table 8-1

WORLD POPULATION	
Birthrate	= 311,000 per day
Death rate	= 138,200 per day
Gain in population =	______ per day

☐8-7. What is the daily gain in the world's population?

Apparently, people-counting isn't a very rewarding occupation. One person just can't keep up with the work. An even more impossible job would be trying to keep up with the needs (food, housing, schools, etc.) of so many people.



People living in cities and towns want such services as electricity, water, and telephones. They want to be able to buy food and drugs from local stores. They need airports, schools, hospitals, fire and police protection. They need jobs as a source of income.

You have seen that when people live close together, each person's output combines with that of others. The total output can produce serious pollution problems. You also know that the trend is for people to move to cities and to live closer and closer together. Thus, you can expect things to get worse in the future.

The rest of this chapter highlights some of the kinds of problems you may have to help solve when you get older. Try to examine each problem break from as many different viewpoints as possible.

In conducting your investigations and in proposing solutions, keep in mind that your plans will affect many other people. Also, be aware of what your plan will cost. Time is important, too. You should consider how long it will take to carry out your plan. Make use of all you have learned throughout this unit. Use other knowledge you have gained from reading, from television, and from radio. Discuss your ideas with your classmates and teacher.

Some of the problems will require more time and effort than others. But each one provides the occasion for creative solutions. They should be viewed as opportunities for getting experience in facing the kind of problems the students will encounter as adults.

Hopefully, students will see and respect the viewpoint of others. They may discover that tactful persuasion and publicity are sometimes more effective than regulations as means of overcoming some environmental crises.

PROBLEM BREAK 8-1

A strange insect that spreads a rustlike disease has suddenly attacked thousands of acres of crops in your area! The farmers want to use large-scale sprayings of insecticide to kill the insects, save their crops, and prevent further spread of the rust disease.

Other people are protesting the use of the insecticide. They are afraid that it will poison the soil and water for years to come. They are also afraid that the wind may carry the poisonous chemical into your town and onto nonfarming lands. To avoid these dangers, they suggest that the farmers burn their crops, thus killing the insects. Of course, the farmers' crops would be a total loss. And because the farmers borrow from the town's banks and buy in the town's stores, the townspeople would lose money, too.

What are the advantages and disadvantages of the two choices? What would you suggest as a solution?

VOTE
INDUSTRY

WITH SOME POLLUTION	WITH SOME POLLUTION
☐	☐
FOR	AGAINST

PROBLEM BREAK 8-2

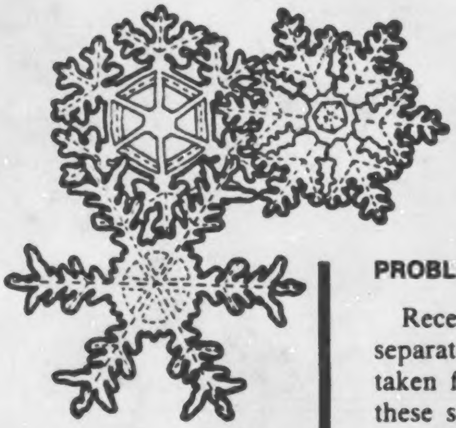
The state of Noname has a small population. It has many farms but little industry. The amount of tax money the state gets is not enough to give each child a good education. Not much can be done for the poor or aged. Potholes fill the roads, more bridges need to be built, few fish and game animals are stocked, and state hospitals are such old firetraps that the governor wouldn't stay in one when he was sick.

A well-known electricity-producing industry has discovered a large deposit of hard coal. Unfortunately, the deposit lies in one of Noname's state recreation areas, beside the largest lake in the state. The industry feels it is an ideal place for a new power plant. The coal could be taken from the park by surface-mining and used as fuel. The cool, clean water from the swimming and boating lake could be used to operate steam turbines. The heated and polluted water would then be released back into the lake.

The industry agrees to sell to the state at a low price all the electricity produced. Tax money to the state would increase by 25 percent. Surrounding states could buy surplus electricity, bringing in more money. Furthermore, many other industries would soon move into the state because they could obtain cheap power.

What are the advantages and disadvantages of bringing in this industry? What limitations, if any, would you place on such an industry? Suppose Noname's state legislature must decide for or against the industry. As a state legislator, how would you vote? Why?

With your help, students should begin to appreciate the magnitude of the questions and the complexity of solutions. Note the opposing factions, and the constraint for the student to see both sides. Experience has shown that in Problem Break 8-1 there is quite a difference in the way students from a rural situation and those from an urban setting react to this problem.



PROBLEM BREAK 8-3

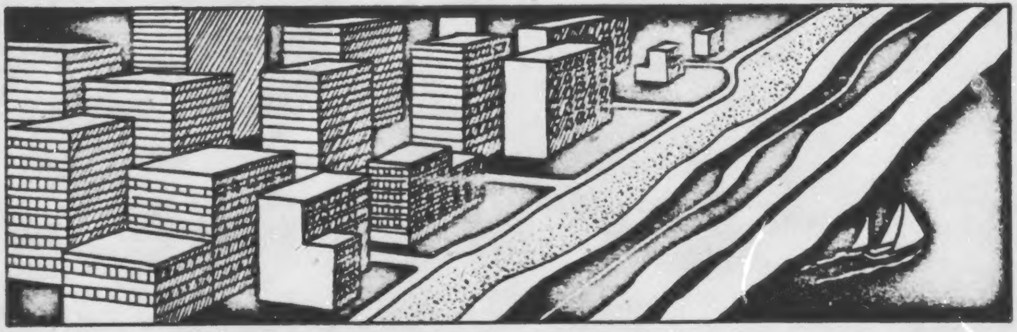
Recently, samples of snow crystals were taken from widely separated areas of the United States. Some samples were taken from remote wilderness areas. Chemical analysis of these samples showed that lead particles were present in every region from which the samples were taken. It is believed the lead particles had been released to the air in automobile exhaust gases. The water in the clouds then formed ice crystals around the tiny lead particles.

Lead is a poisonous metal. It can accumulate in the bodies of living organisms and cause damage and even death.

As a member of the air-pollution control board of your state, what steps do you recommend be taken to control the release of this poisonous substance? What will be the effects of your suggested controls on the automobile industry? How will the citizenry be affected?

PROBLEM BREAK 8-4

Assume that the community in which you live is located on the seacoast. As the population increases, your town is faced with the problem of garbage and trash disposal. The city engineers and the townspeople disagree on how to dispose of the garbage. Several different proposals have been made to the city commission. They include the following:



1. Hauling the garbage out to sea and dumping it
2. Using trash and garbage to fill part of the bay and provide additional building sites
3. Using trash and garbage to fill low lands around the town and make them suitable for building sites
4. Compressing the trash and garbage into blocks and then covering them with concrete and using them as building materials

Of course, this problem break is applicable to all garbage disposal problems, and not just those of a seacoast community.

What position would you take on each of these suggestions and why? What alternative(s) would you suggest?

PROBLEM BREAK 8-5

The amount and variety of noise increases daily. High noise levels damage buildings as well as the human ear. Lower noise levels are sometimes irritating and may lead to an inability to think or sleep. Other effects of noise pollution are described in **Excursion 8-1**. You may want to take that excursion as you work in this problem break.

Excursion 8-1 should prove interesting to most students. It gives some useful background on sound pollution, and is especially relevant to ninth graders.

EXCURSION

Your city is likely to be as noisy as any other. Trucks, aircraft, motorcycles, and other noisemakers are bound to have their effects on your ears. As a community decision-maker,

1. what limits do you recommend be placed on noise sources?
2. what good and what bad effects would such limitations have?
3. should noise polluters be fined or punished just as air and water polluters are? If so, how?

In order to answer these questions intelligently, students need some of the information supplied in Excursion 8-1. In this respect it could be considered remedial in nature.

Every once in a while someone suggests that you can control the population of large cities by building new and smaller cities in less-populated parts of the country. They say that large industries could be invited to build factories in each new area, providing jobs for the new residents. Supporting businesses, such as groceries, utility companies, clothing goods, and so on, would move in to supply the needs of each new city. The planners would limit each new city to a certain size based on the predicted population increase. Of course, pollution control could start as soon as the first citizens arrived. Utopia?

PROBLEM BREAK 8-6

This problem break tends to be aimed at group activity more than the others were. A group of three or four could cooperate. Then the solutions formulated could be compared with those of other groups. On the basis of the ensuing discussions, the written plan could take shape.

Suppose you are one of the planners for such a city. You are to help decide where it is to be located and what large industries to include. Setting up systems for water supply, sewage control, power, and transportation are all under the control of your planning group. Location of industries, businesses, schools, and so on, must also be decided by you and the other planners.

Talk with several classmates as you set up a study group for the planned community. If done correctly, this task will take much time and effort. Assume your city will start with 500 families. Permit a slow increase in new families during the next twenty years. Each family should average four members. Here are just a few of the problems you will face:

1. How will you select those who are to settle in your town?
2. From where will the city receive its food and water?
3. How will the people and industry be taxed?
4. What form of government will the city have?
5. What responsibility will your city have to the nearest neighboring towns?
6. What recreational facilities will be provided?
7. What will be the city's source of power?
8. How far ahead should you plan?

"Satellite City"

SAVE
our
PLANET

Hundreds of other questions could be listed. You will soon see that being a city planner is a tough job. Good luck to you and your group.

Your task won't be complete until you and your group have prepared a written plan. Be sure to include sketches of the proposed layout for the city. Don't forget to plan ahead!

The problem breaks you have completed contain a very important message. They point out that the solutions to environmental problems are far from simple. Understanding and dealing with pollution involve concepts in science, economics, politics, and sociology. Simple solutions to such difficult questions are very unlikely. Many points of view must be taken into consideration. And emotional reactions must give way to reason. Decisions must be based on the best information available.

Notice that the student is being reminded of the interdisciplinary nature of the problem breaks. Science alone cannot solve the problems facing humanity. You may want to use teachers from other departments as resource people for the students.

If time and interest permit, some of your students may wish to "localize" the unit further. You should encourage this, but be sure to keep abreast of their work. With the interest and emphasis being placed on pollution today, there is no limit to what the students can do.

Too often the student has no real idea of his day-to-day accomplishment in school. This list can serve as a good check, and can summarize for him the main points of the entire unit.

Perhaps you, your classmates, and your teacher have thought of other environmental problems to investigate. You may wish to study problems that are currently being faced in your local area. Try tackling some of the kinds of difficult questions that are faced by the men and women who guide your community. It will help you understand the problems they face. It will also help prepare you to handle tough problems.

You have read and done a lot as you completed this unit on *Environmental Science*. You can consider that you have accomplished a lot if you

1. understand better the way the environment and living organisms interact.
2. see more clearly how living things depend on each other.
3. can identify causes of pollution.
4. know some of the effects of air, water, and soil pollution on living things.
5. realize that population increases require immediate, long-range planning to control man's effects on his environment.
6. recognize the difficult nature of the problems men and women face in providing a good life for their families.
7. can appreciate the importance of testing different ideas and viewpoints in seeking solutions to man's problems.
8. have learned that there are times to compromise and times to stand up for your ideas.

Before going on, do Self-Evaluation 8 in your Record Book.

Excursions

Do you like to take trips, to try something different, to see new things? Excursions can give you the chance. In many ways they resemble chapters. But chapters carry the main story line. Excursions are side trips. They may help you to go further, they may help you go into different material, or they may just be of interest to you. And some excursions are provided to help you understand difficult ideas.

Whatever way you get there, after you finish an excursion, you should return to your place in the text material and continue with your work. These short trips can be interesting and different.

115

EQUIPMENT LIST

None

PURPOSE

To explain the cause of the Black Death and show its effect on world population.

A Real Killer

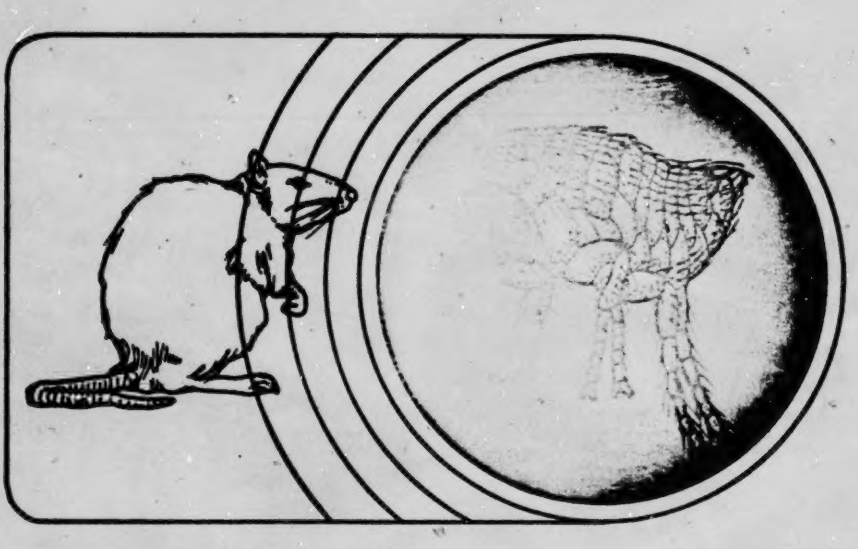
Excursion 1-1

This is a general interest excursion.

The Black Death, now called *bubonic plague,* is a disease spread by fleas infected with the bacteria *Pasteurella pestis.* The bite of an infected flea transfers the bacteria to the animal bitten. Because rats carry fleas, they help spread the disease from city to city and home to home. The rats themselves may become infected with the disease. The bacterial cause of the disease was not discovered until the 1890's—about five hundred years after the great plague of the 1300's. Even when the bacteria was discovered, it was not known for sure how it was spread. It is now known that the disease can be carried directly from person to person as well as by the flea.

MAJOR POINTS

1. Bubonic plague is caused by bacteria that can be carried by fleas.
2. The disease can spread from person to person, as well as be spread by rats.
3. Overcrowding, poor sanitation, and lack of personal hygiene contribute to the spread of disease.
4. A huge number of people can die as a result of an epidemic.
5. A graphical representation can show population changes better than a table can.



In the 1300's, conditions in Europe were bad. Famine and overpopulation had produced poverty and overcrowded towns and cities. Raw sewage polluted the streets, and sanitary facilities were less efficient than those of Caesar's Rome. Cities were rat-infested, and people were ridden with fleas and lice. Conditions were ideal for the spread of a disease such as the plague.

In its journey across Europe, the plague took a great many lives. You can better appreciate the impact of this great crisis if you plot the data from Table 1 on the grid of Figure 1.

Table 1

Approximate Population (in millions)*	Year	Approximate Population (in millions)*	Year
56	1000	61	1450
58	1050	69	1500
61	1100	81	1550
64	1150	101	1600
68	1200	110	1630**
72	1250	100	1660**
79	1300	120	1700
83	1350		
60	1400		

**Estimated data; actual data unavailable.*

***Note that these figures are not for 50-year intervals.*

Depending on the amount of skill in graphing that students bring with them, you may find that some additional help is necessary. The factors that seem to cause the most trouble are the following:

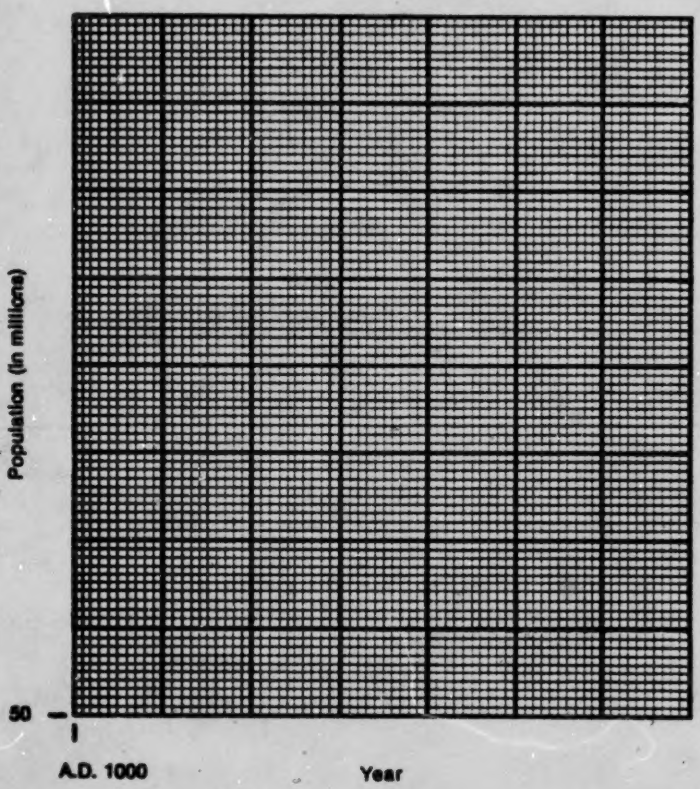
1. **The scales do not start at zero.**
2. **The population figures are in millions.**
3. **The "year" figures are not given in equal intervals.**

Some graphs don't start at zero. As you label your vertical scale on Figure 1, notice that you can label the bottom line "50" (for a population of 50 million). Every *horizontal* line can then stand for an increase of one million in the population. And your vertical scale can take care of a range from 50 million to 120 million people. Label only the lines that show an increase of 10 million population, and your scale won't become cluttered.

The horizontal scale shouldn't start at zero either. Label the left-hand vertical line "1000," and you should be able to complete the scale easily.

☐**1.** As you move to the right on the horizontal scale, what increase in years will you let each thin vertical line represent? each heavy vertical line represent?

☐**2.** Explain why you think it is, or is not, necessary to label on the horizontal scale every year that is listed in Table 1?



☐**3.** According to your graph, when did deaths from the plague occur at the fastest rate?

☐**4.** How many years passed before the population of Europe again rose to the pre-plague level?

☐**5.** What do you think might account for the dip in the graph during the 1600's?

☐**6.** How would you find out if your answer to question 5 is a good one?

1. 10 years; 100 years

2. It is not necessary. As long as you know that each heavy vertical line represents 100 years, and that the intervals between the heavy lines are divided into 10 equal parts, only the heavy lines need to be labeled.

Figure 1

5. The student might infer that another plague hit. He would probably have no way of knowing that this was the so-called Great Plague of 1665 that struck, among other cities, metropolitan London. During some weeks, more than 30,000 people died in this city alone. In July, August, and September of that year over a tenth of the population of London died of it. Schools and universities closed; people fled the city. Isaac Newton, 22 years old at the time, went back to the countryside, and in 18 months, working by himself, laid the foundations of his laws of motion, universal gravitation, optics, and the mathematics of calculus—an interesting consequence of so great a disaster.

Perhaps you would like to do some outside reading on the history of the bubonic plague. Here are a few references:

The Black Death. G. C. Coulton. Earnest Benn Ltd.

The Black Death: A Chronicle of the Plague. Compiled by Johannes Nohl. George Allen and Unwin Ltd.

The Bubonic Plague and England. Charles F. Mullett. University of Kentucky Press.

The Medieval Plague: The Black Death of the Ages. Geoffrey Marks. Doubleday & Company.

Plague and Pestilence in Literature and Art. Raymond Crawfurd. Oxford University Press.

EQUIPMENT LIST

None

PURPOSE

To review or reinforce the particle model of matter from ISCS Levels I and II.

Rearranging Particles Excursion 2-1

This is a remedial-review excursion.

A particle model for matter was introduced in Volume 1 of ISCS, and developed in Volume 2. This model is based on scientific research. It is an attempt to explain the countless observations scientists have made of matter and its behavior. This scientific model attempts to account for the many similarities we see in the appearance and behavior of the substances that make up our world. The model also attempts to explain the differences we observe in substances.

It is impossible to provide all the arguments and reasons for each part of the particle model in the short space of this excursion. But it may be of help to list the different parts of the model, and then to explain a few of the more important ones.

1. All matter is composed of *particles.*
2. All matter is made up of one or more kinds of matter particles called *atoms.* There are 100 or so different kinds of atoms.
3. Substances composed of only one kind of atom are called *elements.*
4. During chemical changes, atoms undergo rearrangement. New substances formed during a chemical reaction are new combinations of the atoms that made up the original substances. These reactions may be accompanied by temperature changes.
5. When atoms combine, they do so in an orderly way. They are selective in combining. Atoms of one kind do not combine with every other kind of atom. When atoms do combine, a definite number of each is involved.

Answers to Checkup on page 8:

The following statements are correct and should have been marked with a check (✓).

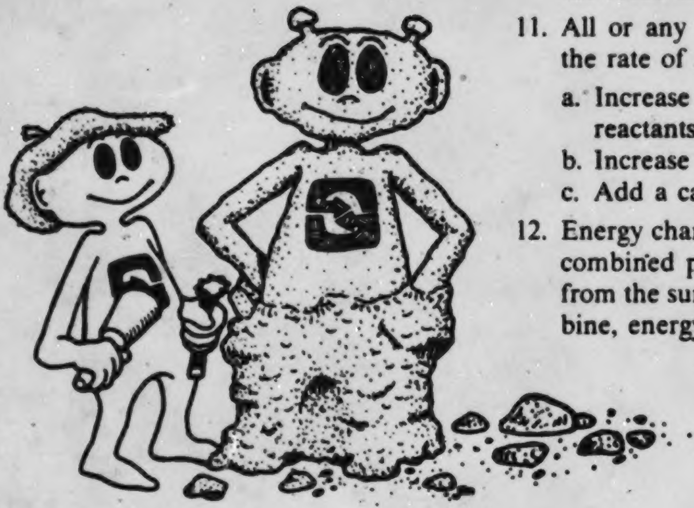
1. a,b,c
2. a,c,d
3. b,c

If you incorrectly marked more than one of the 11 choices for the three questions, you should complete this excursion before going ahead with Chapter 2. It will give you a quick review of the ISCS particle model and how it explains chemical change.

MAJOR POINTS

1. The 12 points of the model are enumerated.
2. Certain parts of the model are emphasized as being more important in environmental studies.
3. Reactants and products in a reaction are redefined.
4. Atoms are conserved; the atoms in the products of a chemical change are the same as those in the reactants.

6. Substances composed of more than one kind of atom combined in definite numbers are called *compounds.*
7. All matter is composed of three kinds of particles containing charge.
   a. One kind of particle has either excess negative or excess positive charge. These particles are called *ions.*
   b. The other two kinds of particles contain an equal amount of both positive and negative charge. They are said to be neutral. These two kinds of particles are called *molecules* and *atoms.*
8. Electrical forces between opposite kinds of charge hold together atoms and molecules, as well as ions, to form elements and compounds.
9. Molecules are made of atoms. Large molecules can be broken up into smaller molecules and even into atoms. And smaller molecules can be combined to form larger molecules.
10. The neutral atoms in a molecule are held together by the force of attraction between opposite charges.
11. All or any of the following can be used to increase the rate of a chemical reaction.
    a. Increase the concentration of one or more of the reactants.
    b. Increase the temperature of the reactants.
    c. Add a catalyst to the reactants.
12. Energy changes accompany chemical reactions. When combined particles are separated, energy is absorbed from the surroundings. When separated particles combine, energy is released to the surroundings.



If you studied Volume 2 of ISCS, you may remember that the particle model for matter and its changes applied to both living and nonliving things. It proved useful in explaining the changes you observed when you studied living creatures such as fish and microscopic organisms.

Each part of the particle model is important. However, there are some parts of the model that need more emphasis. These ideas will help you understand more fully your study of environmental changes.

The model assumes that all substances in nature are made of invisible particles called atoms.

☐**1.** What name is given to substances containing only one kind of atom?

☐**2.** According to the model, how many substances are there that contain only one kind of atom?

☐**3.** What name is given to substances containing two or more different kinds of atoms?

☐**4.** Does the model suggest how many substances there are that contain two or more different kinds of atoms?

4. The model does not suggest the number of substances. Actually the number is astronomical, and new substances are being synthesized all the time.

Because of certain forces resulting from electrical charge, atoms may be attracted to each other. As a result, the atoms form combinations. These combinations are what hold atoms together in elemental and compound substances. Figure 1 illustrates this.

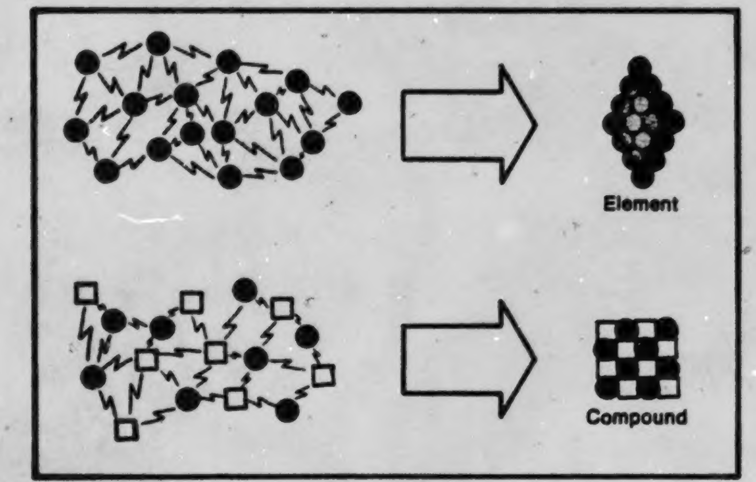
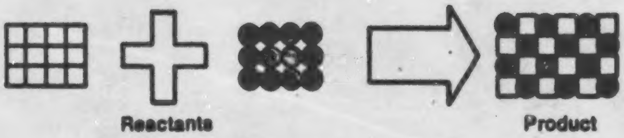


Figure 1

A chemical change is said to have occurred whenever any of the following take place:

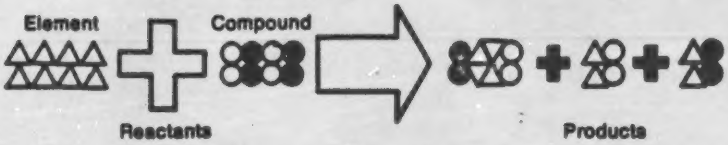
1. Atoms of one element combine with those of another element to form one or more new combinations.

Figure 2



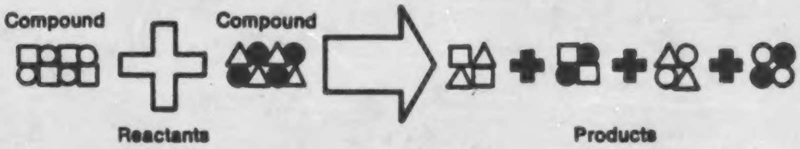
2. Atoms of one or more elements combine with atoms of one or more compounds to form one or more new combinations.

Figure 3



3. Atoms of two or more compounds combine to form one or more new combinations.

Figure 4



In each of the cases, the starting substances and their atoms are called *reactants.* The new substances produced are called *products.* The arrows indicate that products come from reactants.

The atoms in the products of chemical change are always the same as those in the starting reactants. This idea of atom conservation is very important. Check the illustrations in Figures 1 through 4 to see if the symbols show that atoms are conserved.

The particle model says that combined atoms are held together by forces of attraction. If reactants are to be changed to products, a very important thing must happen to the reactant atoms. They must be separated so that they can combine in new ways. Unless new combinations are formed, no new products result. To separate the combined reactant atoms, the forces of attraction between them must be overcome. Overcoming these forces requires an input of energy in some form.

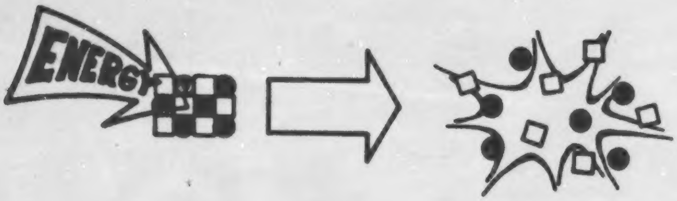
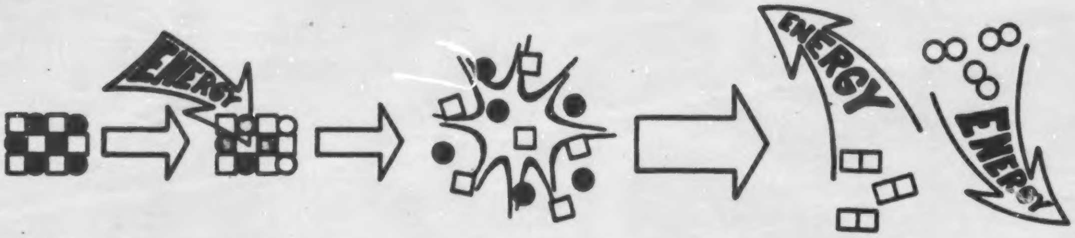


Figure 5

The energy needed to break up combinations of atoms can be in one of several forms. Heat, light, and electrical energy can all be used to separate combined atoms so that chemical changes can occur.

Once the reactants' atoms have been separated, they may then combine in new ways to form products. In terms of energy, these recombinations are the reverse of atom separation. The separating of atoms absorbs (takes in) energy. The combining of atoms releases energy. Figure 6 illustrates the total reaction process.

Figure 6



Temperature changes frequently occur as a result of a chemical change. These changes result from the absorption and release of heat by the reactants.

☐**5.** In which of the following reactions do you predict the temperature of the surroundings will increase? will decrease?

Reaction A: The heat needed to separate the reactant atoms is greater than the heat released when those atoms recombine to form products.

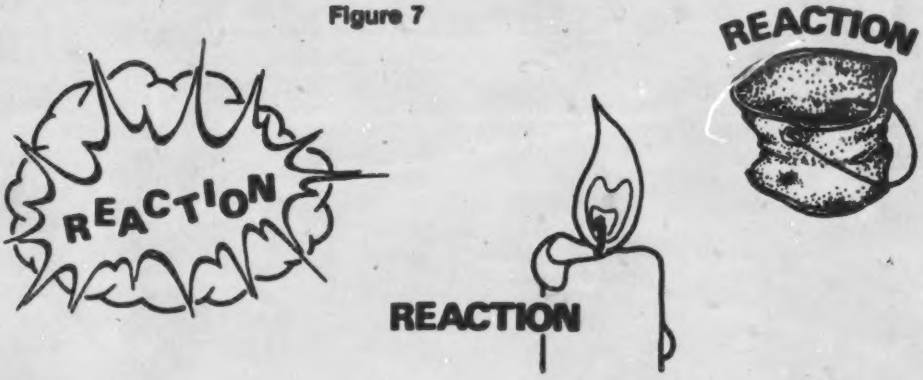
Reaction B: The heat needed to separate the reactant atoms is less than the heat released when those atoms recombine to form products.

5. The temperature of the surroundings will decrease in Reaction A, increase in Reaction B. It is not important for the student to know, but A is an endothermic (heat in) reaction and B is an exothermic (heat out) reaction.

☐6. Suppose a chemical reaction resulted in no change in the temperature of its surroundings. What would you predict about the energy absorbed and released by the reacting atoms?

You should be aware of another important characteristic of chemical reactions—their rate. The *rate* of a chemical change refers to how fast the reaction occurs. Some reactions occur so rapidly and violently that we refer to their rate as "explosive." Some reactions occur at a rapid but steady rate. And some reactions are very slow indeed.

Figure 7



Most of the chemical reactions you witness from day to day vary from slow to reasonably rapid. Very few are explosive. The slow and rapid reactions can be speeded up, however. There are three ways of doing this.

1. Increase the temperature of the reactants. (It is reasoned that increasing the temperature speeds up the addition of the energy needed to overcome the forces holding reactant atoms together.)
2. Increase the concentration of one or more of the reactants. (Increasing concentration is thought to bring more reactant atoms together faster, thus making reactions occur more quickly.)
3. Add a catalyst. (A catalyst is a chemical that, even in very small amounts, speeds up a reaction. The precise reasons for its effects are not known.)

There are many important implications of these factors that affect rate of reaction. Specifically, Chapters 3, 7, and 8 are directly concerned with concentration (of microorganisms and people) and Chapters 5 and 8 with temperature (of air and water).

Items 1 and 2 will be the most important of the three to remember for your work in this unit.

Now return to your work in the chapter.

EQUIPMENT LIST

None

PURPOSE

To investigate possible results of man's attempt to affect the relationships between organisms for his own benefit.

Bounty Hunters

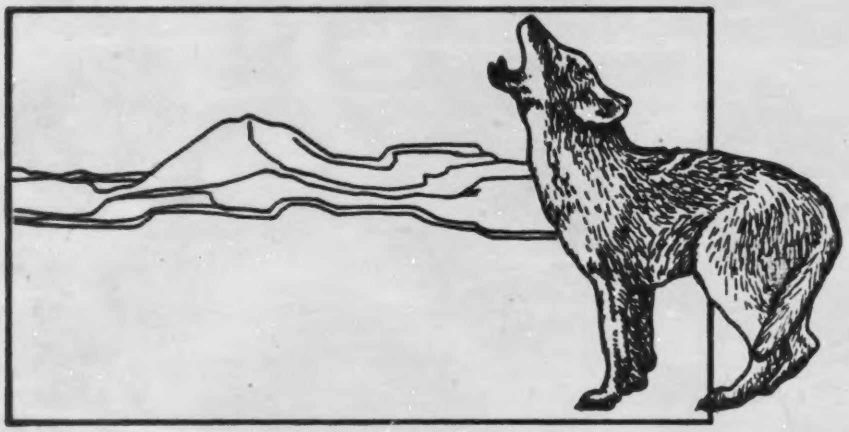
Excursion 2-2

This is a general interest excursion.

MAJOR POINTS

1. It is possible that coyotes do more good than harm in keeping other organisms under control.
2. Extensive study must be done before an intelligent decision can be made on controlling the environment.

"Wanted—Dead or Alive." Such signs are to be found throughout the United States. However, they no longer apply to outlaws. Instead, they are aimed at certain animals that some men believe should be eliminated. These include such animals as wolves, coyotes, hawks, and mountain lions. Because these predators sometimes feed upon man's livestock, they have a "price on their head" in many states. Should these predators be killed? What happens when these animals are eliminated? This excursion will help you answer these questions.



The coyote is a common doglike animal that lives in parts of the region shown in Figure 1.

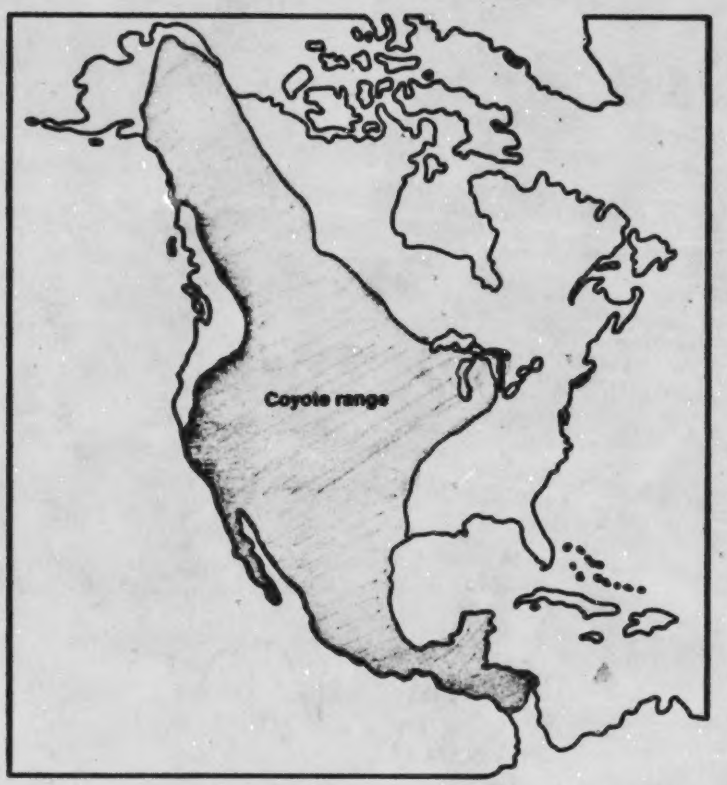


Figure 1

Once occupied by buffalo and sage hens, this region now supports cattle and chickens. The coyote and some other carnivores (meat eaters) have shifted their feeding habits to include the new domestic organisms. Farmers and ranchers claim that millions of dollars worth of livestock are destroyed annually by coyotes.

Supporters of the coyotes don't question the fact that they kill livestock. However, they suggest that the coyotes do more good than harm by eating large numbers of rodents. Because of this coyotes help keep the population of these smaller plant-eating animals under control.

When rabbits or rodents are common, coyotes may not eat all of every one they kill. When rabbits or rodents are scarce, however, coyotes usually consume all of each catch. It is estimated that a coyote eats about 125 cottontails and 15 jackrabbits a year. The coyote may indeed save grass for the rancher's animals, because each rabbit would otherwise be eating the grass that cattle or sheep might eat.

This excursion should not be looked upon as an exercise in "choosing up sides" between farmers and ranchers, and conservationists. The focus should be on the interaction of organisms in their environment, and the difficulty in making intelligent decisions concerning problems of this nature.

Some estimates comparing the amount of plant material eaten by rabbits, cows, and sheep are shown in Table 1.

	Number of Rabbits it Takes to Eat as Much as:	
	One cow	One sheep
Jackrabbits	75	15
Cottontails	250	50

Table 1

☐**1.** How many cows could be fed on the grass that each coyote saves when he eats his year's diet of cottontails? his year's diet of jackrabbits?

1. Each coyote eats 125 cottontails per year. The 125 cottontails would eat as much as $\frac{1}{2}$ a cow would eat (2 coyotes would eat enough cottontails to "support" one cow). Each coyote also eats 15 jackrabbits per year. The 15 jackrabbits eat as much as $\frac{1}{5}$ of a cow would eat (5 coyotes would eat enough jackrabbits to "support" one cow).

Suppose a region has a population of 25,000 coyotes and an ample supply of rabbits.

☐**2.** How many cottontails would 25,000 coyotes eat annually? How many jackrabbits?

2. 25,000 coyotes would eat 3,125,000 cottontails and 375,000 jackrabbits per year.

☐**3.** How many additional sheep could graze on the grass saved by the coyote? (Assume only sheep are raised in the region.)

3. 3,125,000 cottontails would eat as much as 62,500 sheep, and 375,000 jackrabbits would eat as much as 25,000 sheep. The grass saved by 25,000 coyotes could feed a total of 87,500 additional sheep.

☐**4.** If only cattle were raised in the region, how many additional cows could be fed by the grass saved by the coyotes?

4. 17,500 additional cows could be fed by the grass saved by the 25,000 coyotes.

Coyotes do a good job of controlling the population of rabbits and rodents. Without the coyote, these populations would be likely to increase at a high rate.

☐**5.** How would such an increase affect the amount of grazing land needed to nourish a cow?

6. The 25,000 coyotes could save ranchers $437,500.

☐**6.** Suppose it costs about $25 per cow each year to provide grazing. How much money could 25,000 coyotes save ranchers each year for the cattle in the region being studied?

Of course, this is only part of the story. If rabbit and rodent populations are very small, a coyote may eat chickens and an occasional calf or sheep. They may also eat insects, berries, prickly pears, and even mud!

Answers to questions 7 and 8 will vary. The student should be able to come up with his own conclusions. Economically, additional information on the value of livestock killed by coyotes would have to be available before a decision could be made. However, there are other considerations besides the economic ones.

☐**7.** Write in your Record Book your conclusions concerning the good and bad points of coyote control.

☐**8.** What additional information would you like to have before you can decide whether bounties should be paid for dead coyotes or whether it should be made illegal to kill coyotes?

EQUIPMENT LIST

None

PURPOSE

To examine our source and use of water and to raise questions on the conservation of this natural resource.

A Drink of the Nile

Excursion 3-1

This is a general interest excursion on the important subject of the water cycle.

Some of the water in your last drink may once have been part of the Nile River. As impossible as it may sound at first, it makes sense when you look at the never-ending movement of water. Figure 1 shows the so-called water cycle. The important thing to observe is that the water is used over and over again.

Notice that water falls to earth as precipitation (rain, snow, sleet, hail, etc.).

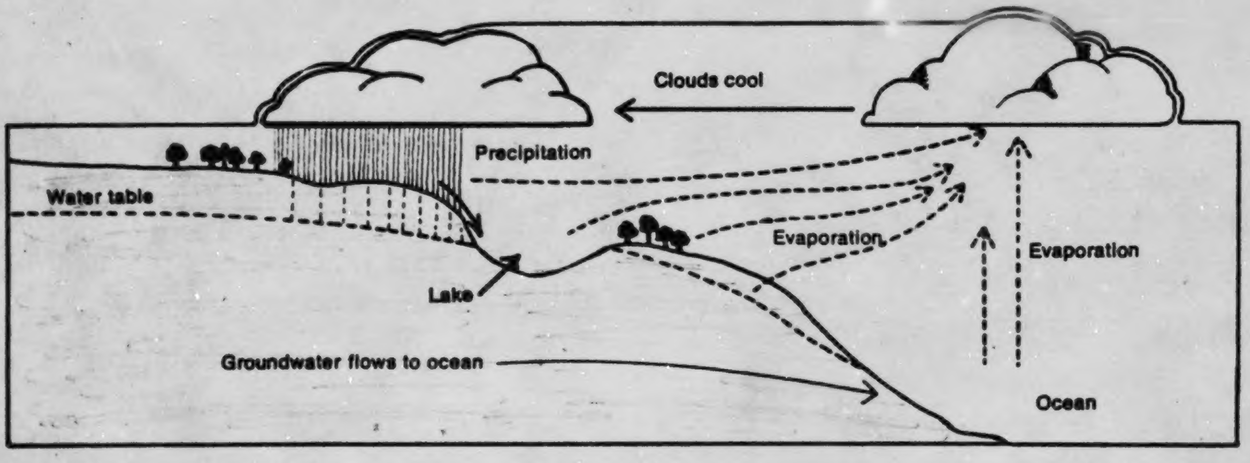
☐**1.** Once having fallen to earth, where might water go?

☐**2.** How does surface water get back into the air?

MAJOR POINTS

1. The replenishment of surface water by precipitation is not uniformly distributed across the country.
2. Many factors affect the availability of water in a given region.
3. Three major uses of water are domestic, agricultural, and industrial.
4. The demand for water is increasing at a rapid rate.

Figure 1



Look closely at Figure 2 and you will see that precipitation does not occur evenly in the United States.

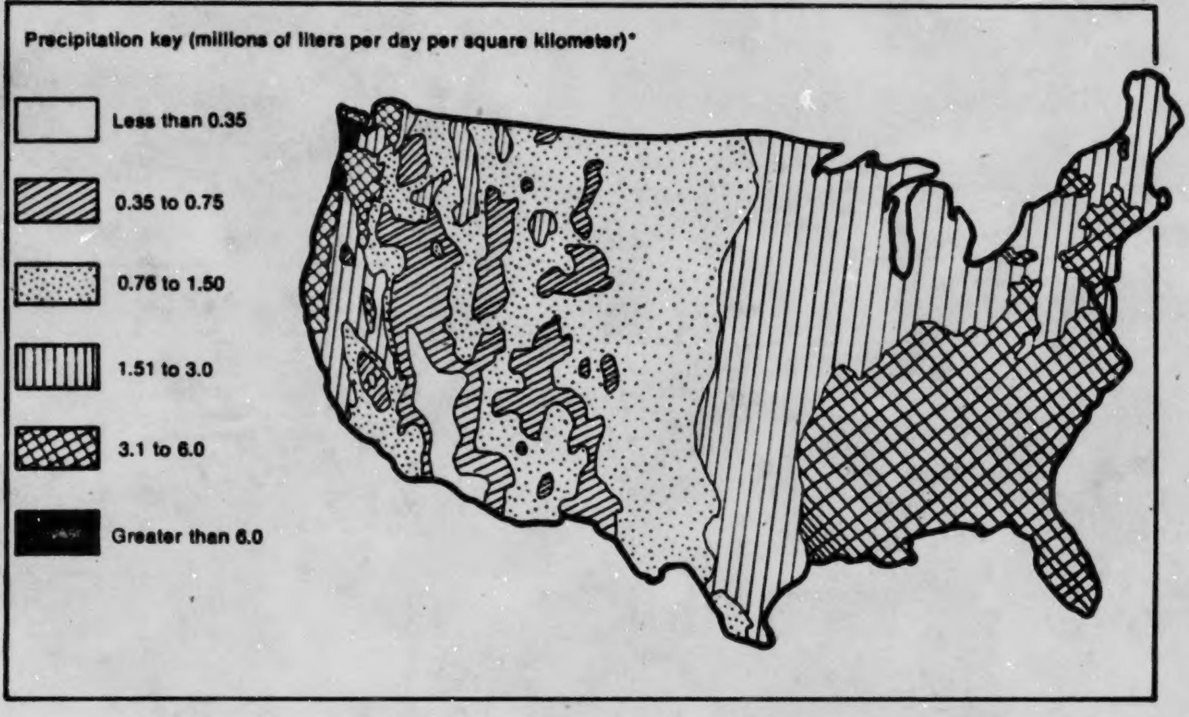

Precipitation key (millions of liters per day per square kilometer)*
Less than 0.35
0.35 to 0.75
0.76 to 1.50
1.51 to 3.0
3.1 to 6.0
Greater than 6.0

Figure 2

4. The Pacific Northwest
5. The Death Valley area in the Southwest receives the least rainfall.
6. Accept any answer. The student would not be expected to know that these large differences result mainly from topographic (mountain) interference with the flow of wind over the surface of the earth.

☐**3.** According to Figure 2, what is the approximate average precipitation where you live?

☐**4.** What sections of the country receive the greatest precipitation?

☐**5.** What sections of the country receive the least precipitation?

☐**6.** How do you explain the large differences in precipitation?

The amount of precipitation is not the only factor that affects the amount of water available in a given region of the country. Climate, soil types, amount of runoff into the sea, and population also have their effects. As a result, some areas have a surplus of water, while others have a water deficiency. The effect of humans on the supply of water is a serious one.

Just how much water do people use daily? Table 1 shows the average amount of water used in some everyday activities.

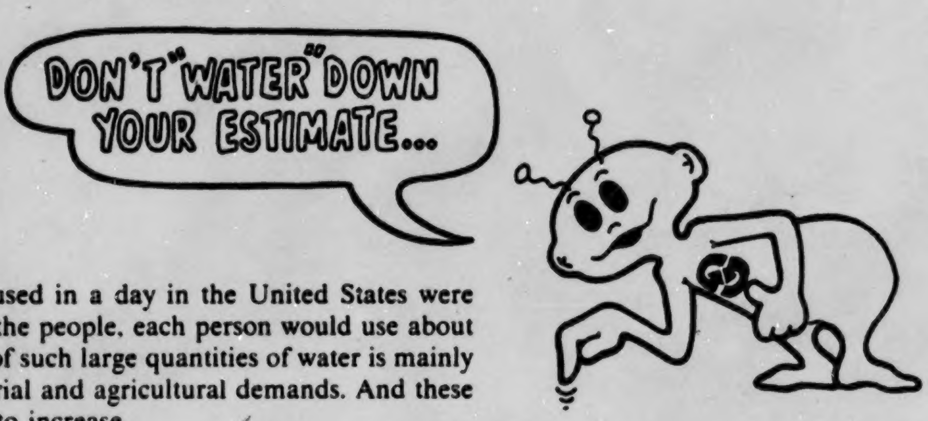
Table 1

AVERAGE DOMESTIC (HOME) WATER USE IN THE UNITED STATES

Purpose	Amount (liters per person per day)
Flushing toilets	78
Washing and bathing	70
Kitchen use	11
Drinking water	10
Laundry	8
General household cleansing	6
Gardening	6
Washing the car	2

It is pointed out below that the use of water by the public includes more than is shown in this table. If these figures are totalled, they amount to 191 liters per person per day. But this only represents *some* daily activities. If all public use is included (that is, all use other than industrial and agricultural) the figure is about 575 liters per person per day.

☐**7.** How much water do you estimate that you use daily?


DON'T "WATER" DOWN YOUR ESTIMATE...

If all the water used in a day in the United States were divided up among the people, each person would use about 575 liters. The use of such large quantities of water is mainly the result of industrial and agricultural demands. And these demands continue to increase.

☐**8.** What is the total average daily domestic water use in the United States? (Assume a U.S. population of 210,000,000.)

Table 2 shows how the demand for water has increased in the United States this century.

Table 2

AVERAGE DAILY WATER USE IN THE UNITED STATES

	Type of Use (billion liters per day)			
Year	Domestic	Agriculture	Industry and Steam Electric Utilities	Total Water Use
1900	19	76	57	152
1920	32	212	103	347
1940	50	269	198	517
1960	106	510	605	1,221
1980*	127	673	1,046	1,846

**Estimated*

☐9. According to the data in Table 2, what trend is evident in water usage?

☐10. What activity used the most water in 1900? in 1960?

☐11. Which category in Table 2 has increased its demand for water the most?

Today almost twice as many people live in the United States as did in 1920.

☐12. How does the increase in water use relate to the increase in population during this century?

10. In 1900, agriculture used the most. In 1960, industry was the biggest user.
11. Industry has increased its demand the most, both in numbers (548) and in percent (1061%).
12. The increase in water use is much greater than the increase in population. While the population doubled, domestic use has increased almost 4 times, agricultural almost 3 times, and industrial about 8 times since 1920.

The demand for water will certainly continue to increase. This increasing need raises many serious questions. Will there be enough water available to supply a growing population? What can be done to conserve our present water supplies? How can we find new ones? Can water be redistributed so that it is available where most of the people live? Will it be possible to desalt ocean water cheaply? Can polluted water be made usable again? These are just a few of the questions that you and your classmates will face and pehaps help to answer during your lifetime.

EQUIPMENT LIST

- All the germinated seeds from the control dishes in Chapter 4
- Soil mixture
- 1 hand lens
- 1 millimeter ruler
- 2 one-quart milk cartons
- 5 teaspoons of powdered or liquid detergent
- 3 planting containers
- 2 paper towels
- 1 rubber band

PURPOSE

To investigate the effect of watering healthy plants with detergent solution.

Clean Vegetables?

Excursion 4-1

This is a general excursion.

MAJOR POINTS

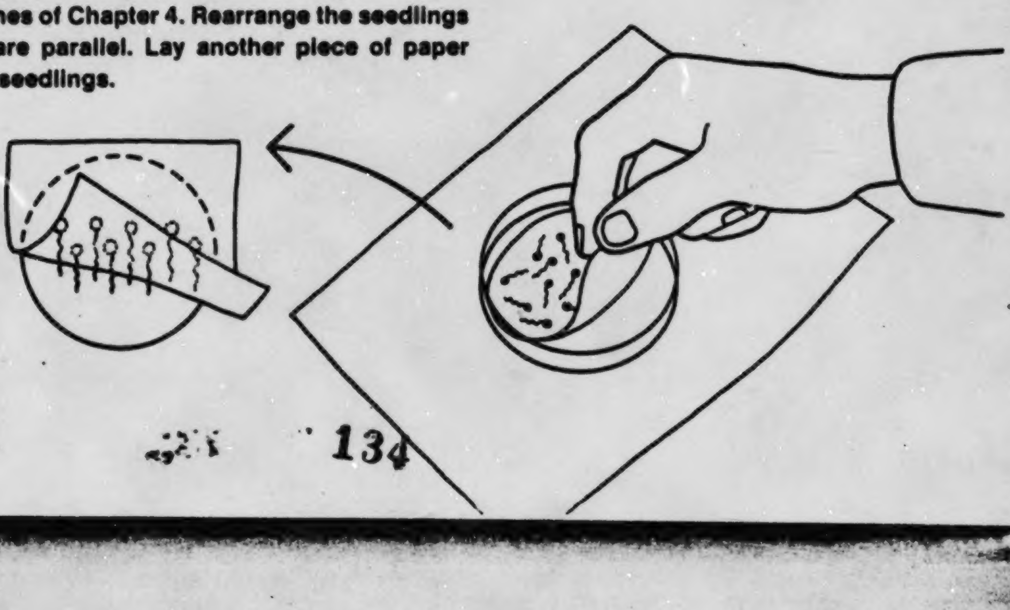
1. Various methods can be used for measuring plant growth.
2. Variables that can affect plant growth must be controlled in the investigation.
3. Detergents affect radish growth in proportion to their concentration.

Suppose you planted some healthy seedlings in soil. And suppose you watered them with water containing detergents. What effect do you think this treatment would have on the growth of the plants? This excursion will help you answer this question. You will need the materials listed below. (Your teacher may allow you to take your materials home for this investigation. If so, take only those items you know you don't already have at home. If you do your work at school, skip Activity 2. Remember to water and observe your plants each day during the weekends.)

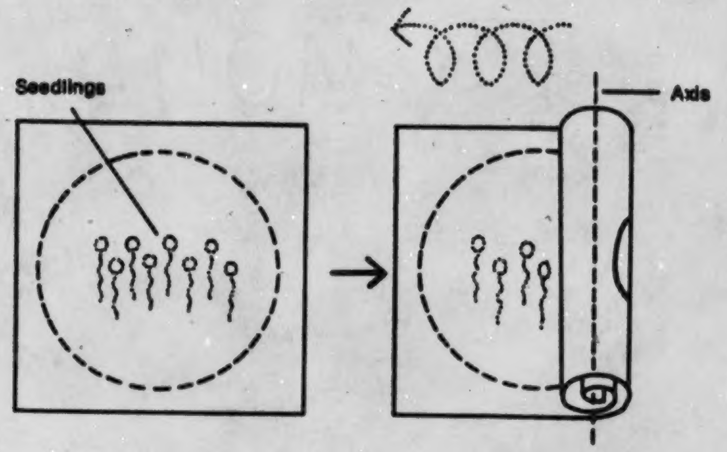
- 20 radish seeds (or all of those that germinated in the control dish from Chapter 4)
- Soil mixture (Obtain as needed.)
- 1 hand lens
- 1 millimeter ruler
- 2 one-quart milk cartons or bottles
- 5 level teaspoons of powdered or liquid detergent
- 3 planting containers (cans, halves of milk cartons, or styrofoam cups)
- 2 paper towels
- 1 rubber band

The student should be aware that this excursion will require 7 consecutive days. Note that Activities 1 and 2 must be done prior to moving the plants if the investigation is to be completed at home. If done in school, the seedlings need only to be removed from the dishes before continuing with Activity 3. In that case, the 2 paper towels and the rubber band will not be needed.

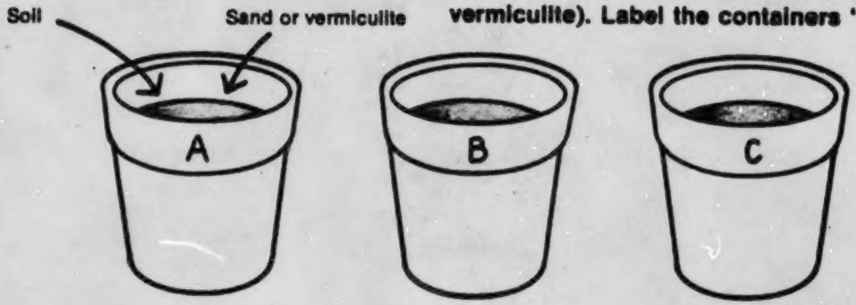
ACTIVITY 1. Remove the filter paper and seedlings from the two control petri dishes of Chapter 4. Rearrange the seedlings so that their roots are parallel. Lay another piece of paper towel on top of the seedlings.



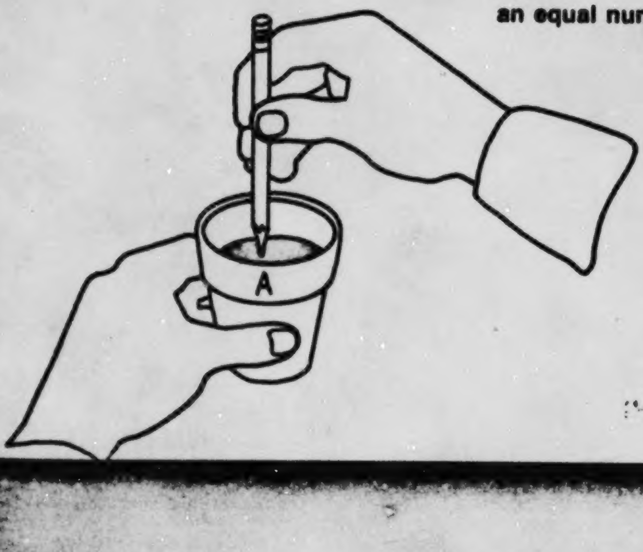
ACTIVITY 2. Gently roll the paper into a cylinder. To prevent breakage, be sure the cylinder axis is parallel to the seedling roots. Wrap another paper towel around the cylinder, and secure it with a rubber band. Your seedlings will now be protected for their trip home.

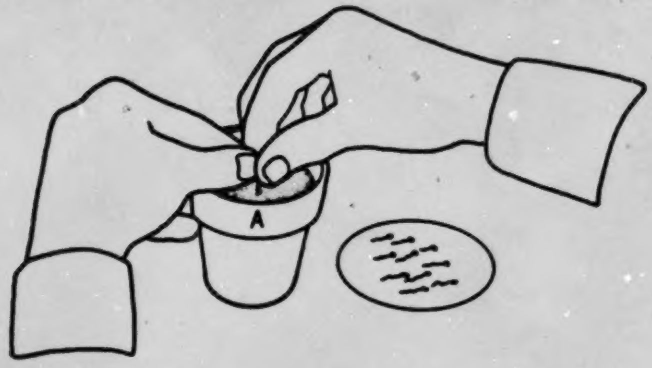


ACTIVITY 3. Fill three containers (cans, cartons, or cups) about 3/4 full of soil mixture (soil and sand, or soil and vermiculite). Label the containers "A," "B," and "C."



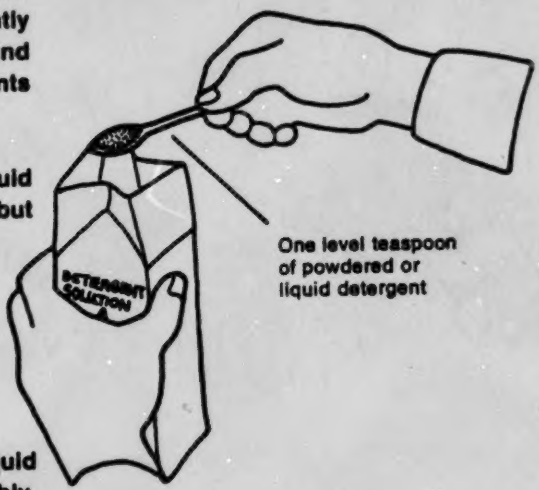
ACTIVITY 4. Punch holes in the soil with a pencil, making an equal number (about 6) in each container.





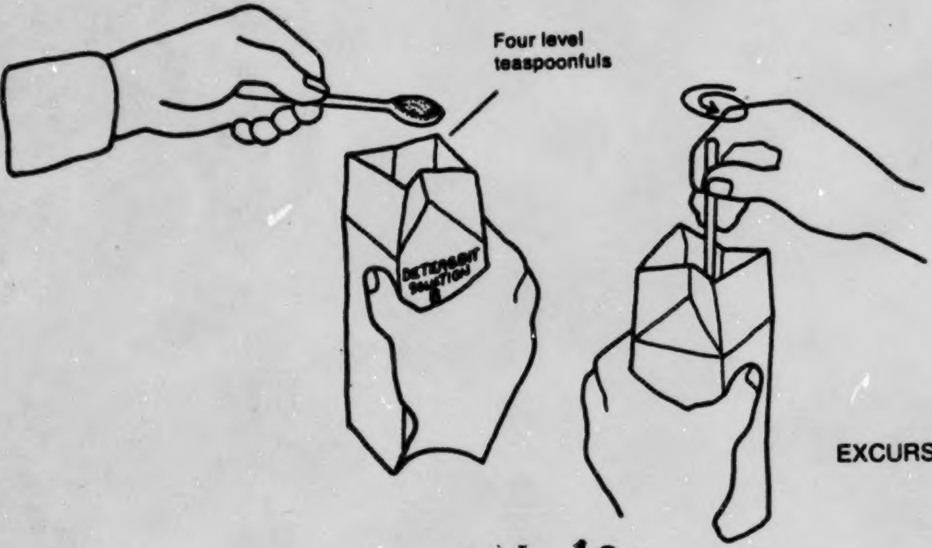
ACTIVITY 5. Plant one seedling at a time. Place it root downward in the hole and push dirt in around it. Do this gently so as not to damage the root. Gently press the dirt around the root. Repeat this procedure for each plant. Plant 6 plants in each container.

ACTIVITY 6. Put one level teaspoon of powdered or liquid detergent into a quart of water. Stir the solution gently but thoroughly. Label the container "Detergent Solution A."



One level teaspoon of powdered or liquid detergent

ACTIVITY 7. Put four level teaspoons of powdered or liquid detergent into the second quart of water. Mix thoroughly. Label the container "Detergent Solution B."



Four level teaspoonfuls

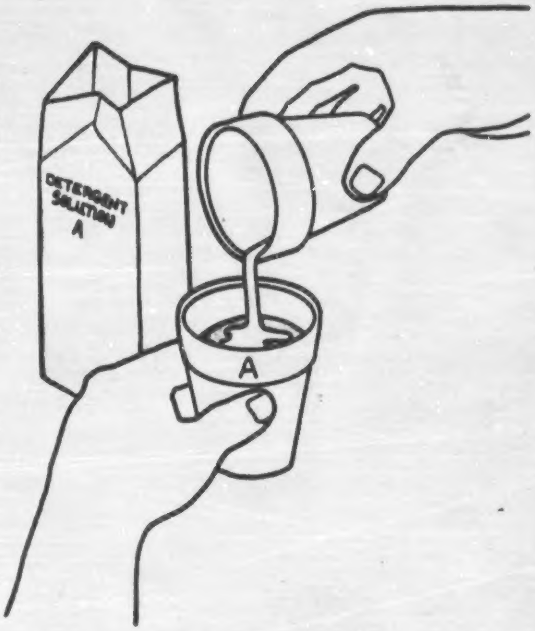
You are now ready to begin your investigation. You should plan to water the plants each day for several days. Follow the instructions in the next two activities. Keep the plants in a well-lighted place but not in direct sunlight. Be sure all get the same amount of light and heat.

A good question for the student to ask himself is, "What are all the factors that could affect plant growth?" These must all be controlled (kept constant), except the liquid that is added to the soil.

You will need to determine your own method of measuring the growth of the seedlings. One measure can be of the plant's height. Record in Table 1 the average height for the group of seedlings in each container. Do this each day for 7 days. You can also check the root growth to see how the plant is doing.

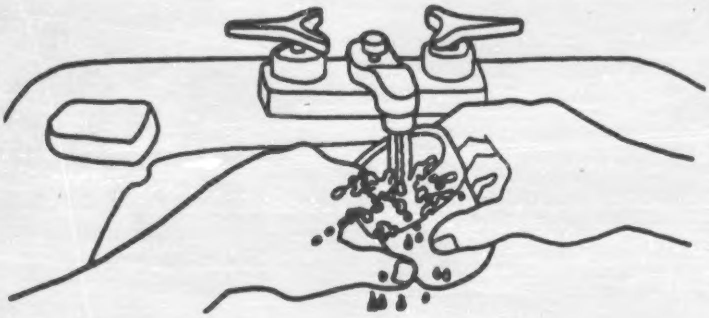
Table 1

		Average Height of Seedlings	General Conditon of Roots	Additional Observations
1 day after planting	Container A			
	Container B			
	Container C			
2 days after planting	Container A			
	Container B			
	Container C			
3 days after planting	Container A			
	Container B			
	Container C			
4 days after planting	Container A			
	Container B			
	Container C			
5 days after planting	Container A			
	Container B			
	Container C			
6 days after planting	Container A			
	Container B			
	Container C			
7 days after planting	Container A			
	Container B			
	Container C			

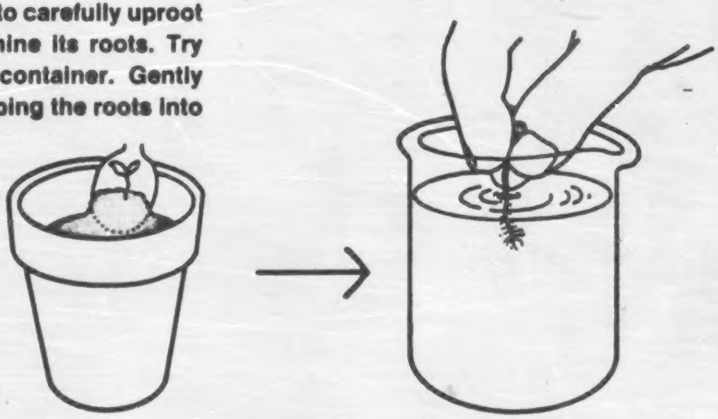


ACTIVITY 8. Each day, after making your observations, water the plants. Plants in container A receive enough of solution A to soak the soil. Those in B receive the same amount of solution B. The plants should not be standing in water. Pour off any excess.

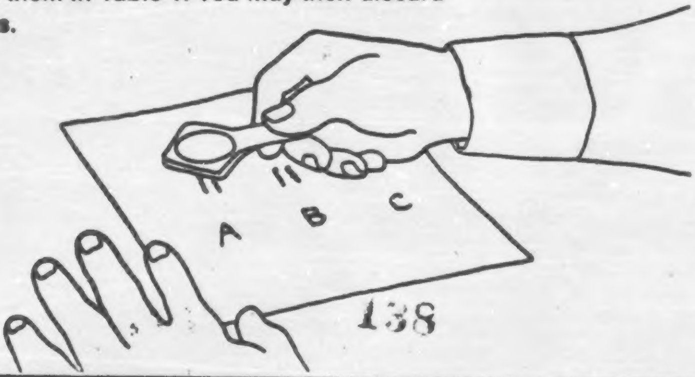
ACTIVITY 9. Rinse the glass before adding enough tap water to container C to soak the soil.



ACTIVITY 10. On the third day, use a spoon to carefully uproot one seedling from each container to examine its roots. Try to select the healthiest plant from each container. Gently remove any soil clinging to the roots by dipping the roots into water.



ACTIVITY 11. Lay the uprooted seedlings on a labeled sheet of paper. Examine them closely with a hand lens. Compare the roots and describe them in Table 1. You may then discard the uprooted seedlings.



Repeat Activities 10 and 11 after two more days, and again after two additional days, uprooting one more seedling from each container each time. Record the results in Table 1.

☐**1.** How do different concentrations of detergent affect the plant development? (Record your conclusions about the investigation in your Record Book.)

☐**2.** In what way, if any, does your investigation suggest you should change your answer to question 4-6 in Chapter 4?

☐**3.** Do you predict that the detergent solutions would have the same effect on other seedlings? Explain your answer.

3. The student has seen an effect of detergent solutions on germination and on growth of radish seeds. There is no basis for a prediction about other seedlings. Accept any predictions. It is possible that some seedlings might be "detergent-tolerant," similar to the way some plants are salt-tolerant.

RADISH
SEEDS

EQUIPMENT LIST

None

PURPOSE

To show some causes and effects of weather conditions on air pollution.

MAJOR POINTS

1. Air pollution, when coupled with certain weather conditions, can seriously affect living and nonliving things.
2. Frequently the air temperature decreases with an increase in altitude.
3. Normal mixing of the air carries the pollutants away from the earth's surface.
4. Under certain conditions there is a layer of warmer air at a higher altitude. This is called a temperature inversion.
5. An inversion can hold pollutants close to the surface of the earth.
6. Advancing cold fronts are a major cause of temperature inversions.
7. When temperature inversions occur over densely populated or industrial regions, smog is likely to form.

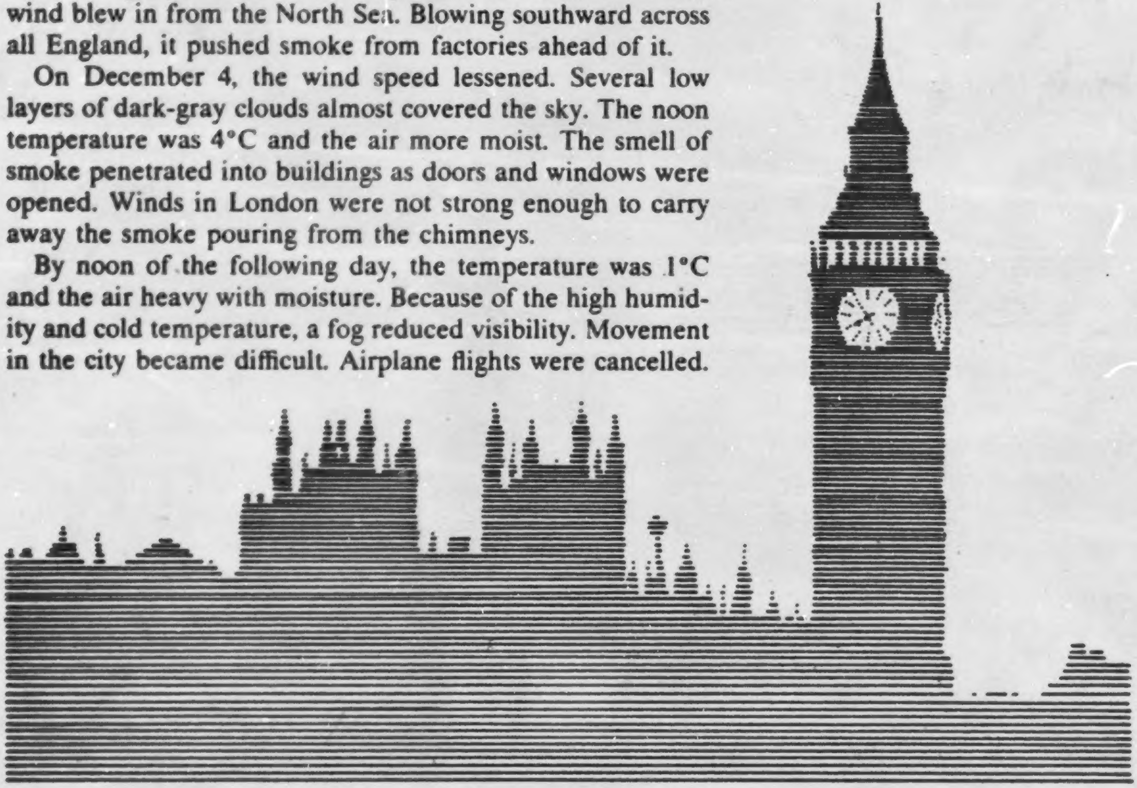
Smoggy London Town Excursion 6-1

This excursion is for general interest and enrichment. There is a good tie-in with the unit on meteorology, "Winds and Weather," in the discussion of temperature inversions.

December 3, 1952, was a beautiful clear day in London. The weather forecasters reported that a cold front had passed during the night. At noon, the temperature reached 6°C. The air was slightly damp, and the sky was full of clouds. A cold wind blew in from the North Sea. Blowing southward across all England, it pushed smoke from factories ahead of it.

On December 4, the wind speed lessened. Several low layers of dark-gray clouds almost covered the sky. The noon temperature was 4°C and the air more moist. The smell of smoke penetrated into buildings as doors and windows were opened. Winds in London were not strong enough to carry away the smoke pouring from the chimneys.

By noon of the following day, the temperature was 1°C and the air heavy with moisture. Because of the high humidity and cold temperature, a fog reduced visibility. Movement in the city became difficult. Airplane flights were cancelled.



Certain areas on the West Coast are bothered by smog. Automobiles and industrial installations dump pollutants into the air. A mountain range can keep the prevailing wind from blowing these products away, and if the air cannot escape the surface, smog often forms. Around the large industrial centers in the East the condition can occur without a mountain range, if the wind is slight and an inversion traps the contaminated air close to the ground.

The rate at which temperature changes with elevation is called the lapse rate. The so-called average, or normal, lapse rate is about 0.006°C per meter. This would be about 1°C per 150 meters, which is the altitude interval in Table 1. As can be seen from the table, the decrease per 150 m varies from 1°C to 5°C, and between 150 m to 2100 m altitude (1950 m) the temperature has dropped from 25°C to −12°C, or 37°. The average lapse rate from Table 1 would thus be about 0.019°C per meter, or about 3 times as great as the normal. This would be called a steep lapse rate.

Very few people tried to drive. Even walking was hazardous. The wet, quiet fog that covered the countryside was loaded with smoke and soot particles. London was the captive of a great *smog*—a mixture of smoke and fog. These conditions existed from December 5 to December 9.

There was no escaping the polluted air. It crept into every room. It irritated eyes and skin, and brought on severe coughing for thousands. Hospitals were jammed with people. During the five days of the fog and in the week following, about 4,000 more people than usual died from lung conditions worsened by the smog.

On December 9, fresh air began blowing in from the south. On December 10, the smog was pushed away by a breeze coming from the north Atlantic.

The smog crisis in London in 1952 is an extreme example of similar conditions that now exist almost daily in many large cities and industrial towns of the United States.

These air-pollution conditions result from a combination of weather conditions and man's output of pollutants into the atmosphere. But how does this combination take place? Perhaps you know some of the answers already.

Table 1 provides data on air temperature taken by a weather balloon at different altitudes. Use the grid in Figure 1 in your Record Book to graph the data from the table.

Table 1

Altitude (meters)	Temperature (°C)	Altitude (meters)	Temperature (°C)
150	25	1200	5
300	23	1350	2
450	21	1500	0
600	20	1650	−3
750	16	1800	−5
900	11	1950	−9
1050	9	2100	−12

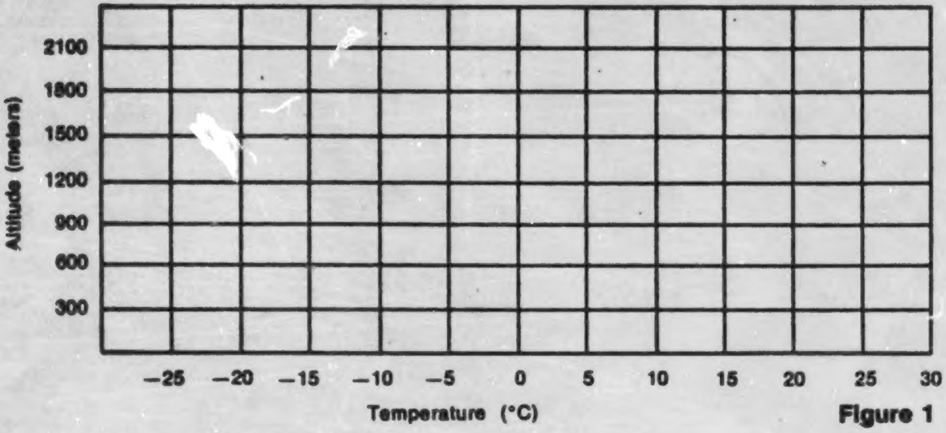


Figure 1

☐**1.** What relationship between altitude and temperature is shown by the graph of the data from Table 1?

1. Temperature decreases as altitude increases.

Frequently, the temperature of air at the surface of the earth is warmer than the air high above the earth.

You may know already that warm air is less dense than cold air. Because of this, warm air is forced upward. Or to say it another way: the mass of a volume of warm air is less than the mass of the same volume of cooler air.

Because it is denser than warm air, cold air falls toward the earth. This pushes the warmer air up. Under these conditions, the vertical (up-and-down) mixing of the air keeps the atmosphere stirred up. When smoke and other pollutants are poured into the air, they rise on these air currents to a distance far above normal breathing heights.

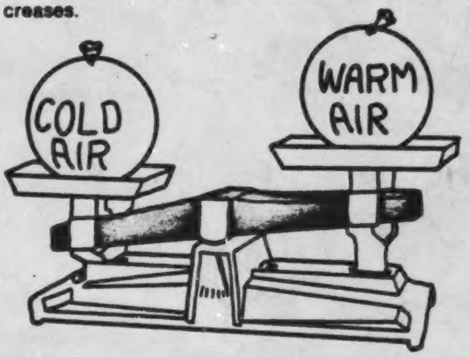
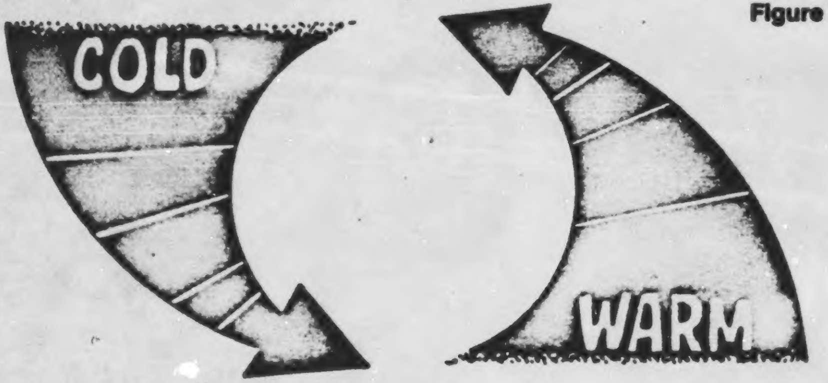


Figure 2



Why did the pollutants in the London air stay near the ground for those five days? Something must have stopped the vertical air motions just described. Let's see what the different conditions were like.

From the description at the beginning of this excursion (you may want to read that part again) you learned that the first weather change in the London crisis was the advance of a mass of cold air over the city. This is called a *cold front.* Figure 3 illustrates what normally happens when colder air moves into a region of warm air. Warm air is lifted up and over the colder air.

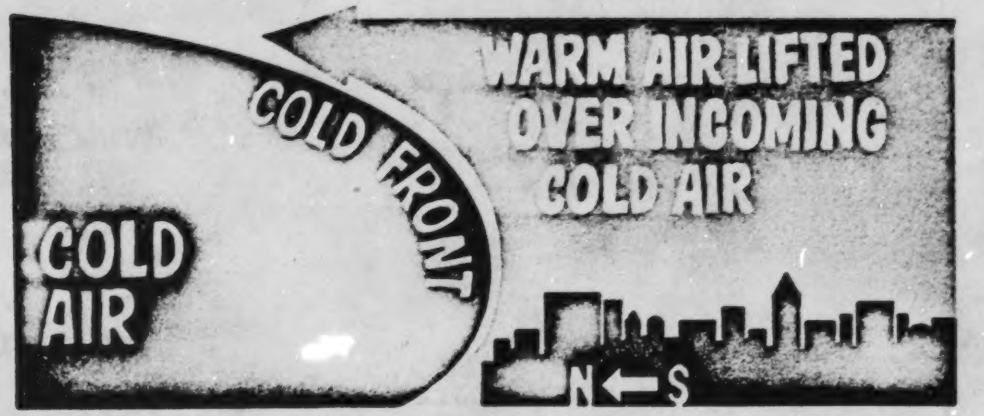


Figure 3

☐**2.** Why does the advancing colder air lift the warmer air?

When a cold front moves into an area, the dense cold air pushes the less dense warm air upward. Soon a cold air mass lies beneath a warm one. This condition is called a *temperature inversion.* Instead of decreasing with altitude, the temperature of the air first decreases, then increases, with increasing height above the earth.

Table 2 contains temperatures like those you would find in a temperature inversion after a cold front has passed through.

Graph the data in Table 2 on the grid of Figure 1 of your Record Book, alongside your first graph.

Note that the second graph is drawn on Figure 1, where the first graph was drawn. You may want to suggest using a different-colored line, or a different kind of line, so that the two graphs can be differentiated.

☐**3.** How is this new graph different from the first one?

3. The most probable answer is that the second graph has a sharp bend in it, while the first one does not.

A distinct layering of air occurs, with the coldest air nearest the ground. See Figure 4.

Altitude (meters)	Temperature (°C)	Altitude (meters)	Temperature (°C)
150	15	1200	0
300	13	1350	−2
450	11	1500	−5
600	9	1650	−4
750	7	1800	−2
900	5	1950	1
1050	3	2100	4

Table 2

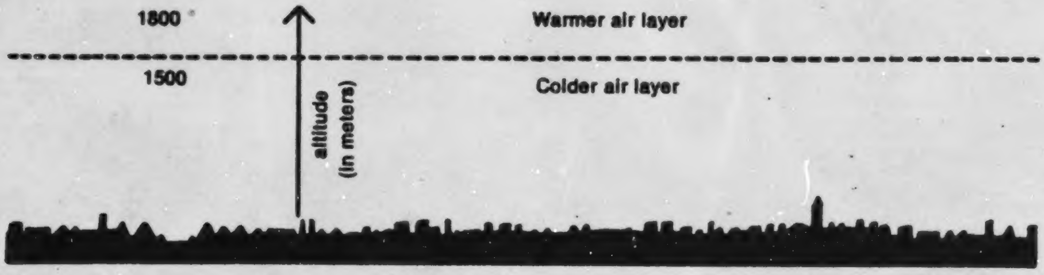


Figure 4

4. Vertical mixing of air disrupts layering. So also, if air does not mix vertically, layering of air results.

☐**4.** Predict how vertical mixing of the air would affect the layering of the air.

☐**5.** Suppose no wind is blowing during a temperature inversion. This means the air will be almost motionless. Where are smoke and other air pollutants likely to collect during a temperature inversion?

When the cold front passed over London in early December 1952, it produced a temperature inversion that prevented vertical air mixing. Since there was no wind to blow the pollutants away, they remained in the colder air layer near the earth's surface. Thus, the pollutants began to collect in the breathing space of man.

☐**6.** Assume that you are the Smog Control Director for London. Would you recommend that the thousands of factory furnaces be shut down whenever a cold front approaches? Why?

Questions 6 through 10. Student responses should be varied and unique. However, in responding and giving reasons, there are several questions that the student should take into account:

1. Is the cost of the practice reasonable, or prohibitive?
2. How much air pollution will be reduced by this practice?
3. Will industry, commerce, and labor be seriously hurt by the costs of the practice?
4. Will the power requirements necessary to operate anti-air-pollution devices be prohibitive?
5. Would curtailment of transportation services or home heating adversely affect the safety of the population?
6. What will be the effect on nearby areas of reducing air pollution by blowing it away?
7. Can any particular practice be put into effect immediately, or will it take a long time to accomplish?

12. Accept either answer. Students will probably have insufficient knowledge of meteorology to effectively compare the effects of cold and warm fronts on smog. The cold front is generally considered the greater contributor to smog.

13. Either could cause an inversion, because both types of fronts are found in temperate areas.

☐**7.** Would you recommend that all motor vehicle traffic be prohibited whenever a cold front approaches? Why?

☐**8.** Would you recommend that artificial breezes be created over the entire city whenever the wind speed dropped to a near zero level? Why?

☐**9.** Would you force London industry to remove solid pollutants from chimney gases before releasing the smoke into the air? Why?

☐**10.** Would you recommend that all home furnaces be turned off whenever an air-pollution crisis occurs? Why?

Discuss your answers to questions 6 through 10 with other members of your class.

You've seen that a cold front can lead to a temperature inversion. Is this the only way a temperature inversion can occur?

Figure 5 shows what happens when a *warm front* moves into an area. Notice that as warmer air moves into a region of colder air, the leading edge of the front is forced upward.

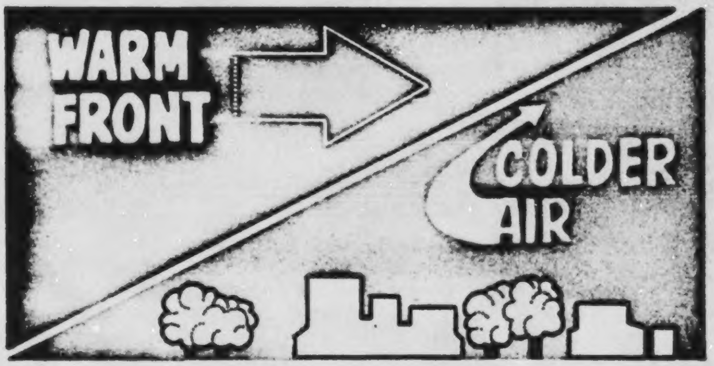


Figure 5

☐**11.** How can a warm front lead to a temperature inversion?

☐**12.** Would you predict that smog conditions would be worse as a result of a cold front, or of a warm front?

☐**13.** Which type of front condition would be most likely to result in a temperature inversion in your own area?

☐**14.** Why are smog conditions less frequent in farming regions than in industrial centers?

EQUIPMENT LIST

None

PURPOSE

To examine the effect of overcrowding on population growth, based on mice in open and closed systems.

The More the Merrier? Excursion 7-1

This is an extension excursion that can provide help in understanding factors affecting population growth.

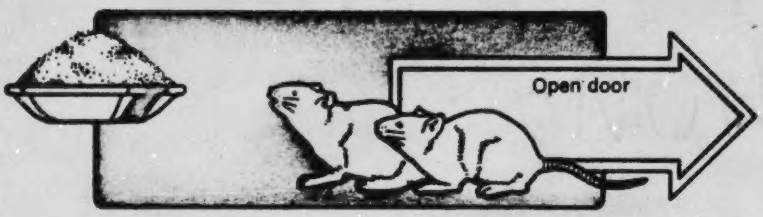
MAJOR POINTS

1. Food supply is an important factor in population size.
2. There seems to be a relation between birthrate and emigration in an open system with a fixed food supply.
3. In a closed system with fixed food supply, birthrate is inhibited when a food shortage develops.
4. With adequate food supply in a closed system, lack of space becomes a limiting factor in population growth.
5. It might be possible for the student to design his own population study.

What happens to people when they live in crowded conditions? There are at least two ways of tackling that question. One way is observing people in overcrowded conditions. The other is experimenting with a simpler animal. One *may* get hints of things to expect in the behavior of crowded humans, by observing overcrowding in animals.

Mice are common laboratory animals. In this excursion, you will learn about some experiments on crowding mice. Perhaps the results of the experiments will suggest something about how people react to overcrowding.

A famous population study was done by Dr. John Emlen at the University of Wisconsin. Dr. Emlen studied a colony of mice that lived in some old buildings. He conducted three experiments (here called A, B, and C). As you read about each of these, judge whether or not good controls were used.



Experiment A

During each day of Experiment A, 250 grams of food were provided for the mouse colony. The buildings in which the mice lived were not sealed. Thus, the mice could come and go as they chose. Because of this freedom, we will call it an "open system." The mice reproduced quite rapidly, and a larger and larger population developed.

For a time, all these "open system" mice remained in the buildings. As the population increased, however, food became scarce.

☐**1.** What might have caused this food shortage to occur?

1. Since the number of mice increased and the amount of food was constant, there was less available food per mouse.

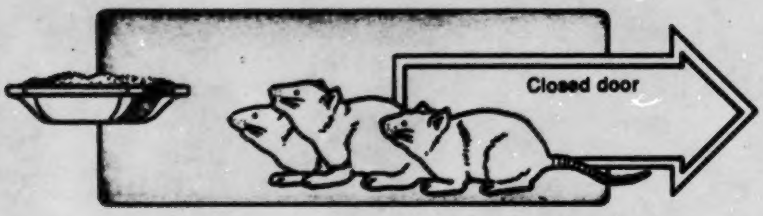
When the number of mice became greater than the 250 grams of food per day could support, some mice left the colony. Emlen found that the rate of emigration (mice leaving the colony) was about the same as the birthrate.

☐**2.** What does this experiment suggest about the effect of food supply on size of population?

2. When there is abundant food, the population will tend to increase. When a food shortage develops, the size of the population must adjust in some way.

☐**3.** Is the rate of emigration a controlling variable on size of population? Why?

3. Yes. *If* mice can leave to find food elsewhere, this leaves more food for those that remain. Thus the size of the population can remain steady.



Experiment B

Dr. Emlen and his associates then performed a similar experiment, except that the mice were kept from emigrating. As before, the population increased. In this case, however, when the food shortage developed, the birthrate went down. The population stopped increasing.

☐**4.** Based on the results of this experiment and Experiment A, how does food supply affect the rate of emigration? What evidence supports your answer?

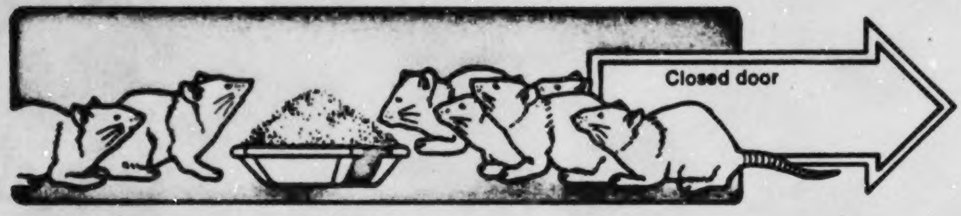
4. Emigration rate increases when available food per mouse decreases. The evidence is found in Experiment A. (This is an inverse relationship.)

☐**5.** What was the relationship between food supply and birthrate when emigration was prevented?

5. Birthrate decreases when available food per mouse decreases. (This is a direct relationship.)

Experiment C

A third experiment was conducted. As in Experiment B, emigration was prevented. But this time a lot of food was provided. As the population increased, the space per mouse decreased. There was less and less space for nests.



During this experiment, the number of mice increased rapidly at first until the mice became crowded. Then fighting and cannibalism shot up sharply. In addition, the females stopped taking proper care of their nests and their young. The death rate among the young reached 100 percent. The birthrate, however, remained high.

☐**6.** Summarize the effects of crowding on Emlen's mice.

☐**7.** How was the size of the population kept in balance?

6. As crowding increases, fighting, cannibalism, and infant death rate increase. (These are direct relationships.)
7. By the three means given in the answer to question 6

Experiments similar to Emlen's have been done many times, usually with similar results. However, in some experiments, fighting and cannibalism did not exist. Instead, the mouse population increased until it reached a maximum size. Then all reproduction stopped.

In all these experiments, the size of the population reached a peak and then leveled off. This was true despite the fact that available food and space could have supported a much larger population. In some cases, the controlling variable was a high death rate. In the others, the controlling variable was a low birthrate.

☐**8.** Can you suggest some reasons why these populations became balanced by widely different means?

☐**9.** What variables might not have been carefully controlled in these two experiments?

8. The reasons that the students give should prove interesting. Possibly the ease of the solution is a factor. For instance, if the system is open, it may be easier to leave than to fight or cannibalize. But if the system is closed, a food shortage leads to a less dramatic control mechanism (decreased birthrate) than does overcrowding. The varying of the experimental conditions causes the differences.
9. Any of the variables listed might not have been controlled. In addition, variables such as temperature, humidity, and the possibility of a different strain of mice entering the open system could be given.

Well, you've seen that crowding affects mice in some definite ways. Some of these ways are listed below:

1. The population leveled off well below the number of mice that the environment could support.
2. Either infant death rate was very high or there was a low birthrate.
3. Very unusual patterns of behavior in the mice became common.

What does this have to do with humans? That's for you to decide. Think through these experiments very carefully, imagining humans living in crowded city or ghetto conditions.

10. It would seem from the mice experiments that overcrowding can cause much more violent conditions than a food shortage can. Unusual patterns of behavior could result with humans under similar circumstances.

☐**10.** If mice could be compared to humans, what do the mice experiments predict about human behavior under crowded conditions? (Record your ideas in your Record Book.)

Emlen's experiments may suggest a procedure for doing your own population study. It can be a very interesting undertaking, but it takes careful planning, good experimental techniques, and much patience. Here are a few key questions you must be able to answer before you begin such an investigation:

1. What organism would it be convenient for me to study? Should it be a microorganism, an insect, a fish, a snail, a bird, or what?
2. How can I care for a population of the organism I choose? Can I study it in its natural environment? Or do I need to provide it with a new home? What kind of food must I provide?
3. What variables do I want to investigate?
4. How can I control the environment to study the effects of my variables?
5. For how long should I continue the investigation?
6. How do I count the individuals within the population?
7. What kind of records should I keep?

Note that the student plan for doing a population study calls for your approval. A study of this kind, properly done, could prove quite difficult and time-consuming. You may want to consider this activity as optional.

There are many other questions you can ask, of course. These are suggested to alert you to be careful in your planning. Think the problem all the way through before you start. When you have your teacher's okay for your plan, you can begin. Keep a good record in your Record Book so that you can report your findings to your teacher and classmates.

EQUIPMENT LIST

None

MAJOR POINTS

1. To be habitable for man, a location must have temperatures within the 0°C to 100°C range.
2. To be habitable for man, a planet or satellite must have an atmosphere containing oxygen.
3. There are no planets or satellites in our solar system known to have the two requisites for man to live.
4. Travel to the nearest star other than the sun would take a prohibitively long time at presently attainable speeds.
5. Cost and other factors seem to make the task of solving the overpopulation problem by space travel impossible.

Escape into Space

Excursion 7-2

PURPOSE

To focus attention of students on the difficulties of solving overpopulation by space travel.

In this excursion you are appointed Director of ISCS. (In this instance, ISCS stands for Into-Space Control Study.) You may invite one of your classmates to be a co-director, since your new job is enormous.

The world population in the year 2000 is expected to approach 7.5 billion people. Some predict more than 20 billion people by the middle of the twenty-first century. If this does occur, there may not be sufficient food on Earth for man. However, many people believe this will present no problem. They believe space travel will provide an escape for man to other planets.

This is a fairly rigorous excursion, for enrichment.

Your mission, should you accept it, will be to make plans and preparations for such travel. Your first job will be to handle the mail arriving from people who want to find a new home away from Earth.

As the new ISCS Director, you must write replies to the questions mailed to the Study by these people. Give each of these questions a brief, honest reply based on the information you find in Tables 1, 2, and 3. And use your own best judgment.

Questions 1 through 11 are taken from the letters. Answer each one carefully, and you will soon be an expert on space travel.

Table 1

TRAVEL GUIDE FOR THE PLANETS

Planet	Average Distance from Sun (miles)	Rotation Period (Earth Units)	Length of Year (Earth Units)	Diameter (miles)
Mercury	36,000,000	59 days (approx.)	88.0 days	3,000
Venus	67,000,000	249 days (approx.)	224.7 days	7,600
Earth	93,000,000	23.9 hours	365.3 days	7,900
Mars	142,000,000	24.6 hours	687.0 days	4,200
Jupiter	486,000,000	9.8 hours	11.9 years	89,000
Saturn	892,000,000	10.2 hours	29.5 years	75,000
Uranus	1,800,000,000	10.8 hours	84.0 years	30,000
Neptune	2,800,000,000	15 hours	164.8 years	28,000
Pluto	3,700,000,000	6.4 days	248.4 years	3,600

Table 2

CONDITIONS ON THE PLANETS

Planet	Mass Relative to Earth	Equivalent Weight of 150-lb person	Composition Of Atmosphere	Approximate Temperature (°C)
Mercury	0.05	55	carbon dioxide	One side 321° Other side −268°
Venus	0.81	130	nitrogen? carbon dioxide, water	Over 260°
Earth	1.00	150	nitrogen, oxygen, water, carbon dioxide, argon	From −87° to +58°
Mars	0.11	55	carbon dioxide, nitrogen? water	Midday 21° Sunset −18° Night −34°
Jupiter	317.8	380	hydrogen, helium, methane, ammonia, water? neon?	Average −129°
Saturn	95.2	160	Similar to Jupiter	Average −143°
Uranus	14.5	155	hydrogen, helium, methane, ammonia? water? neon?	Average −184°
Neptune	17.2	210	Similar to Uranus	Average −194°
Pluto	0.8 (approx.)	Unknown	Unknown	Average −212°

Table 3

TRAVEL GUIDE FOR THE PLANET MOONS

Planet	Known Satellites (in order of distance) from planet)	Average Distance from Planet (miles)	Orbital Time (Earth days)	Approximate Diameter (miles)
Mercury	None			
Venus	None			
Earth	Moon	240,000	27.3	2,200
Mars	Phobos	5,800	0.3	5
	Deimos	15,000	1.3	3
Jupiter	V	110,000	0.5	70
	I (Io)	260,000	1.8	2,000
	II (Europa)	420,000	3.6	1,800
	III (Ganymede)	670,000	7.2	3,100
	IV (Callisto)	1,200,000	16.7	2,800
	VI	7,100,000	251	50
	VII	7,300,000	260	20
	X	7,400,000	264	10
	XII	13,000,000	631	10
	XI	14,000,000	692	10
	VIII	14,600,000	739	10
	IX	14,700,000	758	10
Saturn	Janus	100,000	0.8	Unknown
	Mimas	120,000	0.9	300
	Enceladus	150,000	1.4	400
	Tethys	180,000	1.9	630
	Dione	240,000	2.7	550
	Rhea	330,000	4.5	950
	Titan	760,000	15.9	3,000
	Hyperion	920,000	21.3	100
	Iapetus	2,200,000	79.3	500
	Phoebe	8,100,000	550	100
Uranus	Miranda	77,000	1.4	200
	Ariel	120,000	2.5	500
	Umbriel	170,000	4.2	350
	Titania	270,000	8.7	600
	Oberon	360,000	13.5	500
Neptune	Triton	220,000	5.9	2,300
	Nereid	3,500,000	359	200
Pluto	None			

☐**1.** My friends say it is too hot to be closer than 50 million miles to the sun. They also say that it is too cold to be more than 150 million miles away from the sun. My doctor says I should avoid extremes of cold and heat. Which planets (not Earth, for goodness sake!) could I move to? 1. None

☐**2.** I've seen how the astronauts carry their own oxygen around. I don't think I want to carry oxygen tanks on my back. Which planet should I go to so that I won't need to carry my own oxygen? 2. None

☐**3.** I can't get all my work done in 24 hours each day. Which planet would give me the longest day? 3. Venus

☐**4.** I told your ticket agent I would buy passage if he could send me to a place whose day is longer than its year. He said he could, but he didn't say to what planet. Where is he sending me? 4. Venus

☐**5.** I am twenty years old and anxious to live on Mars. Your agent tells me I will have to change my age to Mars' years. What is my Mars' age? 5. 10.6 years

☐**6.** By careful dieting I have kept my weight at 100 pounds. Your agent said I would be heavier on Jupiter. What will be my Jupiter weight? 6. 253 pounds

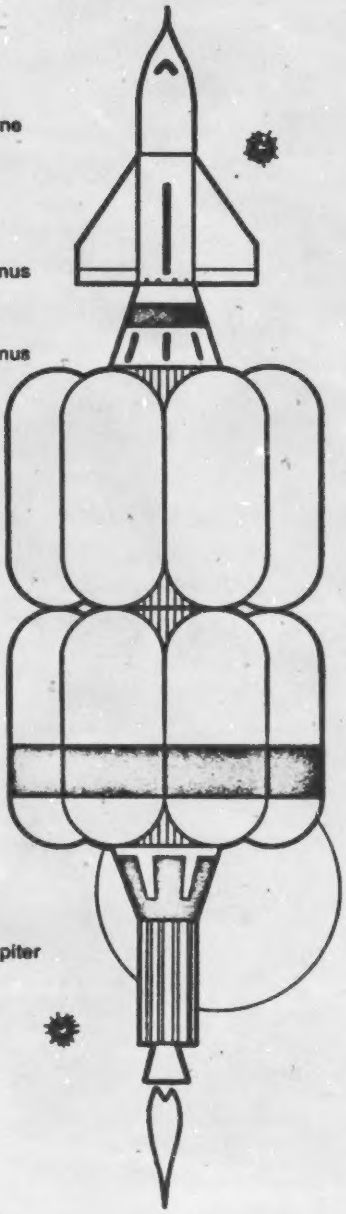
☐**7.** Which of all the planets, except Earth, has the most oxygen in its air? 7. None with free oxygen

☐**8.** I asked in my last letter how fast your spaceships are. You replied that they could travel up to 25,000 mph. How long will it take to get to Neptune? 8. More than 100,000 hr. (4,170 days)

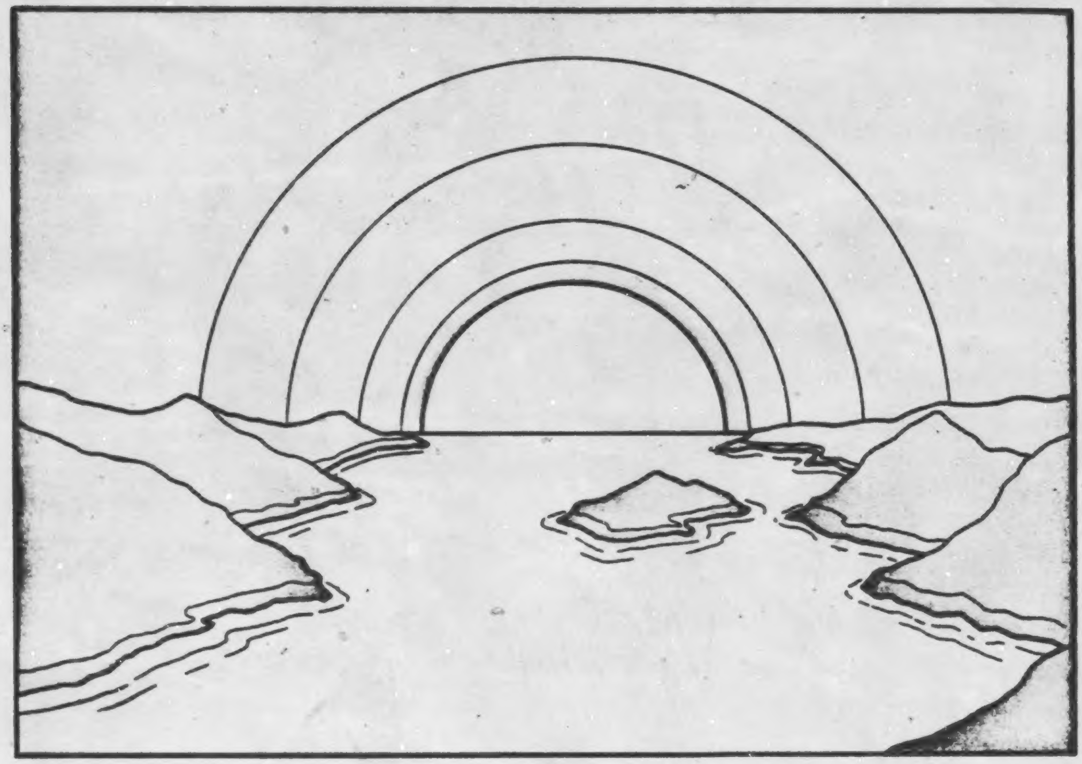
☐**9.** My ticket is marked "To the land of twelve moons, one way only." To which planet will this ticket take me? 9. Jupiter

☐**10.** Why won't your ticket agent sell me a ticket to one of Mercury's moons? 10. There are none.

☐**11.** My husband wants to send me to Nereid on a separate vacation. How big is Nereid compared to Earth? 11. About $\frac{1}{10}$
About how far is Nereid from the sun? Around 2,800,000,000 miles
How far is Nereid from Earth? Around 2,700,000,000 miles
At a speed of 25,000 miles per hour, how long will my trip take, one way? About 100,000 hours
At ten cents per mile, what is it going to cost me? About $27,000,000



After writing answers to these questions, you should be ready to describe a planet or satellite that would be suitable for human habitation. Here are two specifications for such a planet:

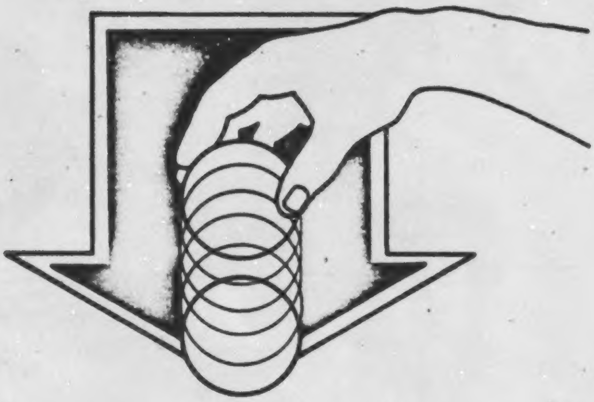


1. To be habitable, any planet or satellite must have liquid water (not ice or water vapor alone). Let's assume that throughout the universe, water freezes at 0°C and vaporizes at 100°C. Therefore, any planet we want to live on must have temperatures within this range.

12. Earth and Mars

☐**12.** Which planets have part-time temperatures within this range?

2. To be habitable, any planet or satellite must have enough gravity to hold gases so that there will be an atmosphere. Among these gases, there must be oxygen. Gases like methane and ammonia are poisonous to humans.



☐**13.** Which planet, other than Earth, has oxygen in its atmosphere?

13. No other planet has free oxygen.

With this information, you should see that your assignment cannot be carried out. There is no place in our solar system that will support populations of humans unless you provide them with an artificial environment.

Wait! Don't close down your operations! Maybe you can send emigrants to planets belonging to other stars.

The nearest star (besides the Sun) is 4.3 light-years away. You may remember that a light-year is the distance that would be traveled if your vehicle were moving at 186,000 miles per second (the speed of light) for one whole year. This distance is about three and a half trillion miles.

Since our present spaceships travel about 6 miles/sec, it would take 600 billion seconds to reach the nearest star. That is about 20,000 years one way.

Some better students may realize that the spacecraft's speed of 6 miles per second is close to the escape velocity from Earth orbit. In free space, with a steady, small, additional applied force, the speed would increase, and much higher rates would be possible.

Students may also have read about time dilation. According to the theory of relativity, and supported by experimental evidence, as a body travels faster and faster, approaching the speed of light, time passes slower and slower for the body. Therefore, at these higher speeds, not only would the spacecraft get to the nearest star quicker, but the elapsed time for the occupants would be only a fraction of the actual time.

☐**14.** Do you believe moving people to other planetary systems will be an answer to the world's population-explosion problems?

14. This is an opinion question, and the student answer will be influenced by his background knowledge. On the basis of available data, the answer should be No.

Let's be very optimistic as we look at the problem from another standpoint. The vehicle that carries three Americans to the moon on each trip is called Apollo. Suppose Apollo could carry 100 people to one of the planets for the same cost as that of carrying three men to the moon. Assuming no change in the growth rate, we would have to export about 70,000,000 people per year in order to hold the present world population constant.

15. More than 190,000

16. More than 1900

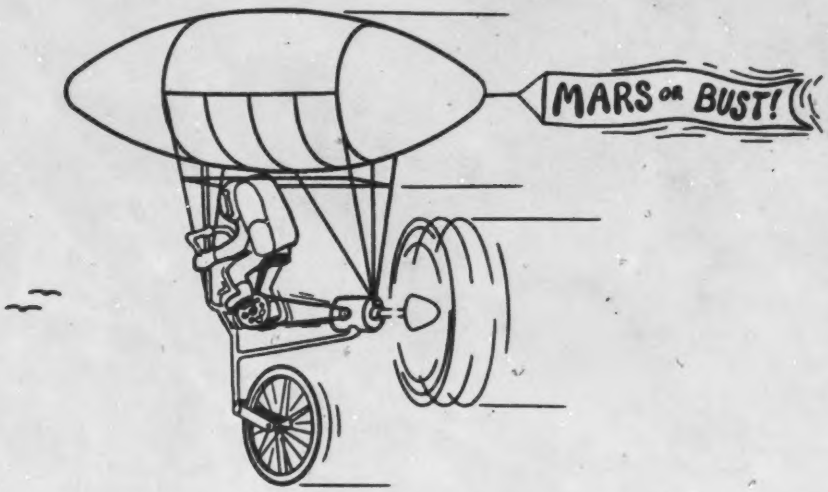
Herein lies the crux of the situation. Within the limits of known scientific laws and principles, mankind can solve the technological problems of space travel if he is willing to spend the time, effort, and money. But if the solution to a problem such as this requires such huge expenditures that there is nothing left for other necessities, it becomes questionable whether or not it is worth it.

☐**15.** How many people would have to leave Earth daily?

☐**16.** How many 100-passenger spaceships would have to leave Earth daily?

The cost would exceed $300,000,000,000 daily, not counting any expenses involved in training the migrants or in preparing a new home for them.

It appears that you will have to resign your job. On the basis of what you know now, you can't move people to new homes on some other planet. Your job is impossible. If your boss doesn't believe your job is impossible, ask him to take this excursion. If you don't know who your boss is, how did you get appointed as Director of ISCS?


MARS OR BUST!

EQUIPMENT LIST

None

PURPOSE

To focus student attention on factors affecting human population growth.

Birthday Control

Excursion 7-3

This excursion is for enrichment.

MAJOR POINTS

1. 40% of the adults in the U. S. believe an ideal family includes four or more children.
2. More than 2 children per couple will increase population.
3. Life expectancy has increased dramatically since early man.

Some people believe there is only one way to avoid the bad environmental effects of the human population explosion. They argue that the birthrate must be decreased to match the death rate. To accomplish this, they insist that parents must take responsibility for keeping their families small.

Such suggestions are not well received by a number of the citizens of the United States. For example, some 40 percent of United States adults believe an ideal family includes four or more children. Is that too large a number if the birthrate is to match the death rate? This excursion will help you decide for yourself.

Suppose there are five sets of parents. In each set there are 12 adults (6 couples). See Figure 1.

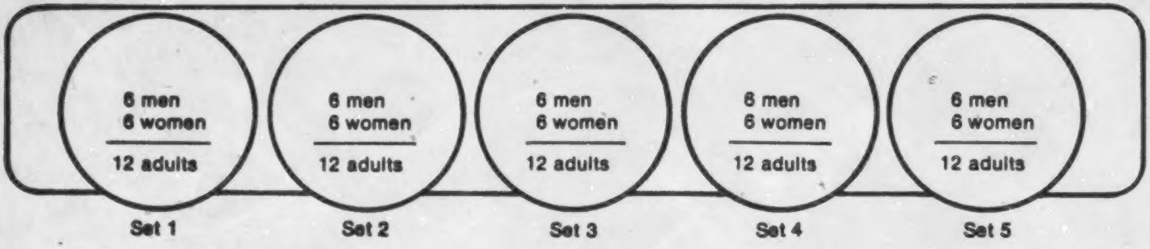


Figure 1

Suppose each set of couples has a different idea as to what is the best family size.

Set 1 prefers having one child per couple.
Set 2 prefers having two children per couple.
Set 3 prefers having three children per couple.
Set 4 prefers having four children per couple.
Set 5 prefers having five children per couple.

Assume that the children, grandchildren, and so on, of each set of parents agree with the original parents on an ideal family size. Using Table 1, calculate the size of the population that results from each set of parents for the next four generations. Assume that at the end of each generation, only the children of that generation are alive (all parents dead). Also, assume that each generation has about an equal number of men and women.

If you come up with an odd number of people in any generation, consider the unpaired individual to be childless.

Table 1

POPULATION CHANGES

Parent Set	Generation				
	Parent	2nd	3rd	4th	5th
1	12				
2	12				
3	12				
4	12				
5	12				

You probably will want to check Table 1, as a number of answers depend on it, in addition to the graphs. For your information, the five lines should be filled in as follows:

1 - 12 - 6 - 3 - 1 - 0
2 - 12 - 12 - 12 - 12 - 12
3 - 12 - 18 - 27 - 39 - 57
4 - 12 - 24 - 48 - 96 - 192
5 - 12 - 30 - 75 - 185 - 460

You may want to suggest that students use different-colored lines or different kinds of lines for the five graphs.

☐**1.** Which of the parent sets will produce an increasing population?

☐**2.** Which of the parent sets will produce a population of steady size?

☐**3.** Which of the parent sets will produce a decreasing population?

Graph the information from Table 1 in Figure 2 of your Record Book. Draw a separate line or curve for each parent set. Label each.

☐**4.** Which of the curves in Figure 2 resembles the world population curve you drew in Figure 7-1 of Chapter 7?

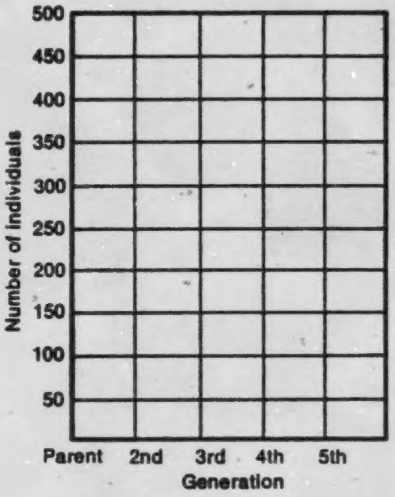
4. The curve for set 5 should most nearly resemble the world population curve.

Suppose you agree with those who argue that the birthrate must not exceed the death rate.

☐**5.** Based on Table 1, what number of children would you recommend for each family?

☐**6.** What effects would unexpected increases in the death rate have if this method of birth control were used?

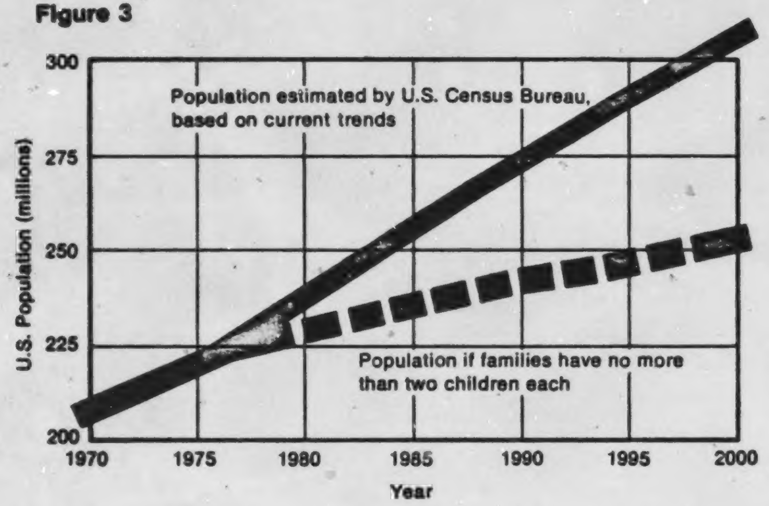
Figure 2



Note that because people are living longer, there would still be an increase in the U. S. population with 2 children per couple.

Do you believe it would really make any difference if there were a reduction in family size in the United States? Study Figure 3 to find the answer.

Figure 3



☐**7.** If present trends continue, what will the United States population be in the year 2000?

☐**8.** If, beginning in 1970, families were to have no more than two children each, what would the United States population be in the year 2000?

☐**9.** What is the difference (in millions of people) between your answers to questions 7 and 8?

The assumption you made earlier about all parents dying, is of course not true in the United States. It is quite common for several generations (grandparents, parents, children, etc.) to be alive at the same time. One reason for this is people are living longer each generation. Study Table 3 to see what has been happening to life expectancy throughout history.

Region and Time	Life Expectancy
Neanderthal Man	29
Classical Greece	35
Classical Rome	32
England, 14th Century	38
England, 19th Century	41
United States, 1900	50
United States, 1940	61
United States, 1970	72

Table 3

☐**10.** What reasons can you give for the increasing life span of humans?

☐**11.** Based upon the trend in Table 3, what do you predict will be the life expectancy for a child born in the year 2000?

11. The trend would seem to indicate a life expectancy of more than 83 by the year 2000. That would be an increase of more than 11 in 30 years, or more than from 1940 to 1970. It is rather interesting to note that a graph of these data can give a very distorted prediction. Except for the drop in the case of Classical Rome, the curve looks very much like the world population curve, and an extrapolation seems to indicate that very shortly life expectancy will be infinite (man will live forever). Incidentally, the way question 11 is asked may lead to some confusion. A child born in the year 2000 will be living (barring unforeseen circumstances) in the second half of the 21st century, and life expectancy may be higher still.

Well, there are more and more people, and their individual life-spans are increasing.

☐**12.** What do you see as the strongest reasons for birth control?

☐**13.** What do you think are the strongest reasons against birth control?

Discuss your answers to questions 12 and 13 with some of your classmates.

EQUIPMENT LIST

None

This excursion is for enrichment and general interest.

MAJOR POINTS

1. Noise can be defined operationally.
2. The loudness of sound is measured in decibels.
3. The higher the frequency, the higher pitched the sound is.
4. Too loud a sound can cause deafness.
5. The average hearing ability of people is defined as "standard."
6. Hearing loss is measured by the amount in decibels above standard a sound must be for a person to hear it.
7. Loss in hearing can result from being in a noisy environment for a long time.
8. Hearing loss generally increases with age.
9. Automobiles and trucks are probably the greatest of all noise polluters.

Ssh! You're Polluting the Environment

Excursion 8-1

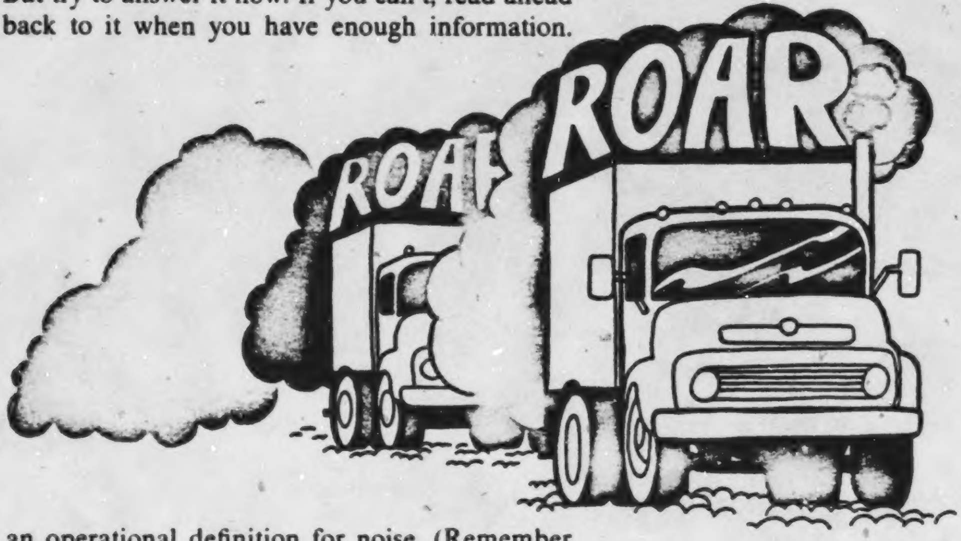
PURPOSE

To provide background on the causes, measurement, and effects of sound on humans.

"My, but it's quiet" is the kind of comment that people who leave a city or town often make. Noise is so much a part of our environment that we tend to ignore it—unless it's very loud or when it's not there. Stop reading and listen for a few moments. Yours is a quiet classroom if you don't hear a dozen or more different kinds of sounds within a few minutes.

All noise is sound, but is all sound noise? Different people probably define noise differently. The next question is a tough one. But try to answer it now. If you can't, read ahead and come back to it when you have enough information.

1. The operational definition will depend on the descriptive definition that is used for *noise*. Generally, it is considered to be a loud, confused, or disturbing sound of any kind. In physics, the emphasis is on irregularity, and noise may be considered simply unwanted sound. After the student has read ahead (if necessary), he should be able to operationally define noise as the maximum reading in decibels on a sound-meter at some specified distance from the source.



☐1. Write an operational definition for noise. (Remember to tell how to tell when noise is present or, better still, how to measure the amount of noise.)

Extremely loud sounds, such as explosions, can cause deafness. But most people never hear sounds that loud. In order to see the effect of more common and less loud sounds, you need to know how sound is measured.

The loudness of sound is measured in *decibels.* Zero on the decibel scale is the quietest sound that can be heard by the best ears. Table 1 shows the decibel value for some common sounds.

The brighter student may wonder about the sound unit "decibel." It was named after Alexander Graham Bell, inventor of the telephone. The bel is a measure of the power ratio of a sound wave, and the decibel is one tenth of a bel.

Table 1

Category of Sound	Loudness on Decibel Scale	Type of Noise
Threshold of Hearing	0–10	Rustling leaves. Light breathing.
Faint	10–25	Whisper at two meters. Quiet office. Empty movie house. Quiet neighborhood at night.
Moderate	25–50	Suburban playground. Restaurant. Average living room. People talking.
Loud	50–70	City playground. Vacuum cleaner. Noisy office. Average traffic.
Very loud	70–90	Portable sander. Food blender. Noisy party. Power lawn mower. City traffic. Garbage disposal.
Deafening	90–115	Rock band. Loud motorcycle. Car horn at one meter. Airplane propeller at takeoff. Jackhammer. Foot of large waterfall. Subway train.
Painful to ear	115–130	Thunderclap. Distant rocket. Siren at two meters. Jet engine revving for takeoff.
Eardrum breaks	130 or more	Jet plane taking off. Rocket engine at close range. Explosions. Large weapons (cannons, machine guns, etc.).

2. It will be interesting to note the rating students give. Do they consider the sound moderate, loud, or even very loud?

☐2. According to Table 1, your classroom has about what decibel level?

As you may know, sound is also measured in frequency. The higher the frequency, the higher pitched the sound is.

☐3. Are high-pitched, or low-pitched, noises more annoying to you?

If you are like most people, high-pitched noises are more annoying to you. Of course, another variable is when a particular sound occurs. Most people can stand a much higher sound level during the day than they can at night.

☐4. What decibel level causes deafness from a single blast?

In answering the last question, you probably referred back to Table 1. The table tells you that the eardrum breaks when it receives sounds at a decibel level of 130 or more. When this happens, a person becomes deaf to most sounds. Take a look at Figure 1 and find the eardrum.

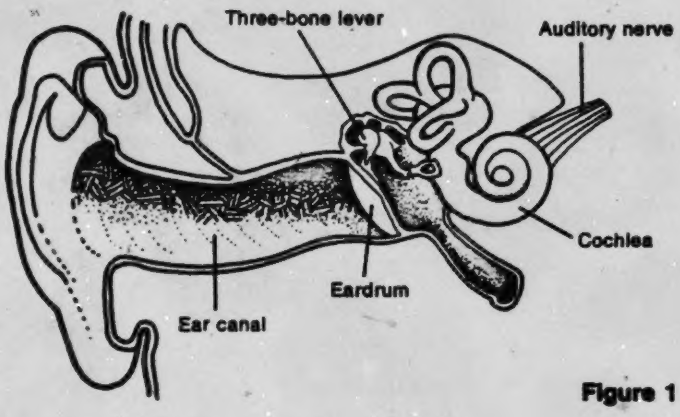


Figure 1

Sounds enter the ear canal and strike the eardrum, causing it to vibrate. These vibrations are carried by three tiny bones to a second membrane in the inner ear. Vibrations of this membrane cause movements in the liquid of the snail-shaped cochlea. When tiny hairs are shaken by the vibrating liquid, nerve messages are sent to the brain.

Many studies have been done on the hearing of Americans. The average hearing ability of people is defined as "standard." Hearing loss is measured by comparing a person's hearing ability with the standard. If, for example, a sound must be 15 decibels above the standard for a person to hear it, he is said to have a 15-decibel hearing loss.

Fundamentally, a sound-level meter used to measure intensity could be simply a microphone connected to a sensitive electrical meter. Of course, other refinements enter in when the measurements are to be used scientifically.

☐5. Describe the hearing of a person who can hear a sound only when it is 43 decibels above the standard.

6. This would be a 6-decibel hearing gain.

☐**6.** Describe the hearing of a person who can hear a sound when it is 6 decibels below the standard.

Figure 2 shows the changes in hearing that can occur from being in a noisy environment (90 decibels) for a long time.

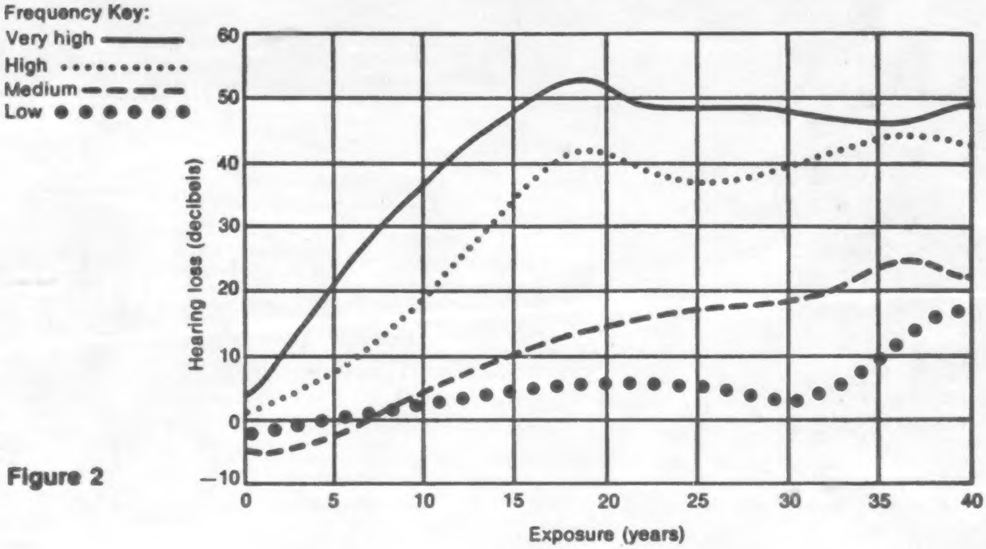


Figure 2

☐**7.** Is there a greater hearing loss at low, or at high, frequencies?

☐**8.** Do hearing losses develop at low frequencies faster, or slower, than they do at high frequencies?

9. The classic occupation with a high decibel reading gave its name to the so-called "boiler-maker's deafness." There are many others, however. Did anyone say "housewife"? A vacuum cleaner can go to 85, an electric dishwasher to 80, and the garbage-disposal unit generates from 90 to 100 decibels.

☐**9.** What kinds of occupations might commonly have a 90-decibel environment?

Most people suffer some hearing loss as they get older, especially for high-frequency sounds. However, being in a noisy environment while aging can make the loss greater. Figure 3 shows the standard hearing loss for high sound frequencies.

10. The best description would be that a 65-year-old person shows a 28-decibel hear- g loss; a 23-year-old shows no loss (hears the standard). But an answer of "28 times as much" is unacceptable.

☐**10.** How would you describe the hearing loss of an average 65-year-old person compared to the average 23-year-old?

Studies have shown that over an eight-hour working day few humans can stand more than 80 to 90 decibels of sound.

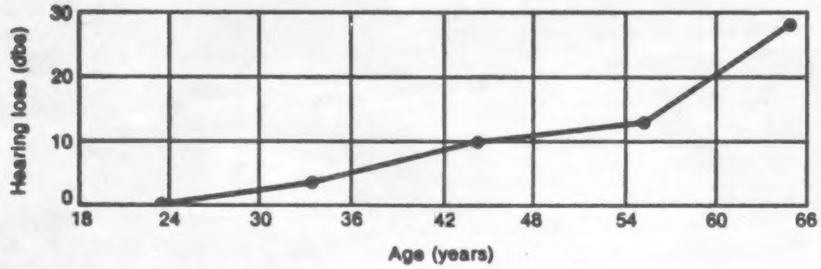


Figure 3

Workers in noisy environments often wear plugs, earmuffs, and other ear protectors. But since this practice started only about twenty years ago, many people are partially deaf who shouldn't be.

Noise has been blamed for high blood pressure, indigestion, social conflicts, high divorce rate, and many other problems. There is a good deal of evidence that sound can cause psychological as well as physical damage. Near large airports some schools have had to be closed because the noise made it hard for the students to think.

In several chapters in this unit, you have studied how the output of automobiles pollutes the atmosphere.

Automobiles and trucks are noise polluters. In fact, they are probably the greatest of all noise polluters. Traffic noise is at or near the top of the list of noises that most people would like to eliminate. Table 2 shows the average noise levels of cars and trucks at a distance of about eight meters from a California superhighway.

Table 2

Noise Source	Average Decibel Level
Automobile, 48 km/hr (30 mph)	68
Automobile, 113 km/hr (70 mph)	81
Trucks, 80 km/hr (50 mph)	105

☐**11.** What is the effect of a car's speed on its noise production?

☐**12.** How does the noise level produced by trucks at 80 km/hr compare with the noise level of propeller-driven airplanes at takeoff?

Reducing the level of sound in our environment is not an easy task. Some people seem to prefer noise, even if it may mean that they will eventually suffer some hearing loss.

Someone has said, "What's one man's Bach in another man's Babel." There is some evidence that the loud music that has been so much in favor by the younger generation is having a deleterious effect on the hearing of this group. And there are many older people who claim that they are being driven crazy by that kind of music.

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